PHASE 2 STUDY
DATA SUMMARY REPORT

for
Libby, Montana

Environmental Monitoring for Asbestos

Evaluation of Exposure to
Airborne Asbestos Fibers
During Routine and Special Activities

March 31, 2006

Prepared by
USEPA Region 8
999 18th Street, Suite 500
Denver, CO

with technical assistance from
Syracuse Research Corporation
999 18th Street, Suite 1975
Denver, CO

This page intentionally left blank to facilitate double-sided printing.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

This page intentionally left blank to facilitate double-sided printing.

1.0   INTRODUCTION

Libby is a community in northwestern Montana located near an open pit vermiculite mine. The mine began limited operations in the 1920's and was operated on a larger scale by the W. R. Grace Company from approximately 1963 to 1990. Studies at the site reveal that the vermiculite from the mine contains amphibole-type asbestos, referred to in this report as Libby Amphibole (LA). Epidemiological studies at the site revealed that workers at the mine had an increased risk of developing asbestos-related lung disease (McDonald et al. 1986, Amandus and Wheeler 1987, Amandus et al. 1987a,b). Although the mine has ceased operations, historic or continuing releases of LA from mine-related materials could be serving as a source of on-going exposure and risk to current and future residents in the area. In support of this, a health study by ATSDR identified a number of individuals in Libby with asbestos-related disease but no known history of occupational exposure (ATSDR 2002a, 2002b).

The U.S. Environmental Protection Agency (USEPA) has implemented several investigations to characterize the nature and extent of LA contamination of the environment in and around Libby. The purpose of this report is to summarize the results of an effort referred to as "Phase 2". The Phase 2 study was conducted in the fall of 2001 and was designed to address a series of questions related to the sampling and analysis of environmental samples, including the following:

> *1) What method is best for collection of air samples?*
>
> Air samples may be collected using either a stationary monitor (located in a fixed position throughout the sampling event) or a personal air monitor (worn by a human as that person moves about). The potential issue is that, in a location where asbestos fibers are present in a source such as dust, soil, or insulation, some types of human activities may tend to "kick up" asbestos fibers into the air, resulting in an increase in asbestos fiber concentration in the breathing zone of the person engaged in the activity. Thus, while a stationary monitor located in the general vicinity of such an exposure may be useful and appropriate for assessing the "passive" exposures of people who are not engaged in the activity, it may tend to underestimate exposures of the people directly engaged in activities which disturb the source material. ***Therefore, the first objective of Phase 2 was to measure asbestos levels in the breathing zone of individuals engaged in routine and special activities in and about Libby, and to compare those measurements to data collected from co-located stationary air monitors.*** This information is intended to help guide future air sampling activities at the site that are needed to evaluate risks to individuals engaged in both routine and special activities in the home.
>
> *2) What method of analysis is best for air samples?*
>
> Air samples (filters) may be analyzed for asbestos by several different methods, including Phase Contrast Microscopy (PCM) and Transmission Electron Microscopy (TEM). The PCM method has been used most extensively in the past, and the current EPA slope factor for quantifying lung cancer risk from asbestos in air is expressed in units of risk per PCM fiber per cc of air. However, PCM has some potential limitations, including the inability to distinguish between asbestos and non-asbestos fibers, to distinguish between different mineral classes of asbestos, or to visualize very thin fibers

1

(<0.25 um). In contrast, TEM can distinguish between asbestos and non-asbestos fibers, can distinguish between asbestos mineral types, and can also identify fibers smaller than those visible by PCM. ***Thus, the second objective of Phase 2 was to analyze a series of different air samples by both the TEM and PCM methods in order to help judge which type of measurement is most appropriate, and to derive a site-specific relationship between the two (if possible)***.

3) Are the levels of asbestos observed in Libby of potential human health concern?

As noted above, the chief reason for collecting data on asbestos fiber levels in air is to support risk assessment and risk management decision-making. ***Thus, the third objective of the Phase 2 study was to utilize the data collected to derive preliminary assessments of the potential health risk to people who engage in the types of routine and special activities investigated during the study.*** It is important to note that, because the Phase 2 study was not intended to be systematic or comprehensive and hence did not span all possible exposure conditions and all exposure locations, the project plan emphasized that the data should be interpreted as providing only an initial estimate of the range of different exposure levels (and hence health risks) that residents of Libby may experience from both routine and special activities.

The data generated from the Phase 2 effort have been utilized in several Risk Memoranda (USEPA 2000, 2001), as well as other site reports and technical memoranda, and have been used to refine sampling and analysis methods in subsequent site investigations at the Libby site. The Phase 2 data are also currently being used to support the Remedial Investigation/Feasibility Study (RI/FS) and the baseline risk assessment (BRA).

Some of the samples collected during the Phase 2 program have been re-analyzed as part of the Supplemental Remedial Investigation Quality Assurance Project Plan (SQAPP) (USEPA 2005a), but the results of these re-analyses will be presented elsewhere and are not included in this report.

2.0   PHASE 2 STUDY DESIGN

The Phase 2 Quality Assurance Project Plan (QAPP) (USEPA 2001) provides a detailed description of the Phase 2 study design. Every reasonable effort was made to adhere to the specified study design and methods for sample and data collection. However, as necessary, the study design and collection methods were optimized in the field based on input from the Libby field sample collection teams and with oversight and approval from USEPA. Study design modifications and field sampling deviations were documented using field modification forms. The field modification forms specific to the Phase 2 study are provided in Appendix A.

The following sections provide a brief summary of the purpose and types of data generated during the Phase 2 study.

2.1   Scenarios Evaluated

One of the main objectives of the Phase 2 study was to investigate the concentrations of asbestos fibers in air that may occur in the breathing zone of individuals engaged in a variety of activities that might lead to the disturbance of asbestos-contaminated source materials such as dust, vermiculite insulation, and soil. To this end, Phase 2 was divided into four general activity-based "scenarios", as follows:

Scenario 1 – Routine Household Activities
Scenario 2 – Active Household Cleaning Activities
Scenario 3 – Active Disturbance of Vermiculite
Scenario 4 – Active Disturbance of Soil (Rototilling Activities)

There were a total of 26 residences in Libby that participated in the Phase 2 study (participation was strictly voluntary). In this report, the residences participating in the Phase 2 study are referenced by a randomly assigned identification code (e.g., Property A, Property B, etc.). Table 2-1 summarizes which residences participated in each scenario, and includes information that was available before Phase 2 began on the occurrence of asbestos contamination in attic insulation, indoor air and indoor dust in these residences.

Scenario 1: Routine Household Activities

Scenario 1 focused on the airborne exposures of residents engaged in routine household activities excluding active cleaning. A total of 16 residences participated in Scenario 1. As seen in Table 2-1, this included residences with and without vermiculite insulation, and residences with and without measured levels of asbestos in indoor air and dust. The types of activities performed during the sample collection period were recorded by the resident in an activity log. Any special activities that were a potential source of increased exposure to airborne asbestos fibers were also recorded in the activity log[1].

---

[1] At one residence, the field activity log noted that the resident engaged in cleaning activities during the Scenario 1 sample collection period, but the duration and intensity of cleaning was judged to be sufficiently small that any impact on the long-term average exposure was likely to be minimal. Therefore, this sample was retained for inclusion in the Scenario 1 analysis.

Scenario 2: Active Cleaning

Scenario 2 focused on active cleaning-related activities (vacuuming, sweeping, dusting) that are likely to cause increased levels of dust (and hence asbestos) in indoor air. A total of 22 residences participated in Scenario 2 (these residences included 13 of the 16 locations participating in Scenario 1).

In addition to the cleaning activities of vacuuming, sweeping, and dusting, an additional cleaning scenario was evaluated at one residence to assess exposures specifically related to beating sofa cushions. In this report, vacuuming/sweeping/dusting cleaning activities are referred to as Scenario 2A and beating sofa cushions is referred to as Scenario 2B.

Scenario 3: Active Disturbance of Vermiculite

Scenario 3 focused on exposures that occur when vermiculite sources are actively disturbed, such as when a contractor performs remodeling or repair work in a home with vermiculite insulation, or when a resident enters a space (e.g., an attic area) with unenclosed vermiculite insulation. Seven residences participated in Scenario 3. Six of these 7 residences had vermiculite insulation in the attic, and samples of insulation from all six of these attics contained detectable levels of LA when examined by polarized light microscopy (PLM) (see Table 2-1).

Scenario 3 exposure activities were separated into the following categories:

> 3A) Sweeping or moving debris/insulation in attic
> 3B) Cutting holes into ceilings or walls (e.g., replacing a ceiling fan)
> 3C) Replacing or removing carpeting
> 3D) Removing vermiculite via hand-bagging
> 3E) Removing vermiculite via vacuum truck

Scenario 4: Active Disturbance of Soil

Scenario 4 focused on exposures that occur when garden soil is actively disturbed during rototilling activities. This scenario was chosen both because vermiculite is known to have been added to a number of gardens in Libby, and because rototilling is a realistic and aggressive soil-disturbance scenario. While the Phase 2 QAPP specified that rototilling was to be performed for three gardens (1 garden without visible vermiculite and 2 gardens with visible vermiculite), the activity was only completed in one garden (with visible vermiculite). The failure to collect data from three different locations limits the application of the data collected since the range of values between locations and conditions can not be assessed, but does not alter the value of the data at the specific location assessed.

2.2   Collection of Air Monitoring Samples

There were several types of air monitoring samples collected during the Phase 2 study. The sections below summarize the different types of air samples collected and the timing of the sample collection. Table 2-2 summarizes the general air sampling design of the Phase 2 study, and Table 2-3 summarizes the types and number of air field samples collected within each scenario.

Personal Air Monitors

Air monitors worn by an individual engaged in a designated activity are called "personal" air samples. Personal air monitors are worn at the breathing zone (about 4 to 6 feet above ground surface). Two types of personal air samples were collected during the disturbance activity. A "full period" personal air sample was collected from the beginning of the disturbance activity until the end of the disturbance activity. The full period sample represents the average exposure during the disturbance activity. Several "excursion" personal air samples were collected at shorter intervals within the disturbance activity when it was suspected that the highest air concentrations might be present.

Stationary Air Monitors

Air monitors placed in a fixed location are called "stationary" air samples. Stationary air monitors were placed in the main area(s) of the residence where scenario-related activities were occurring. During Scenarios 2 and 3, several outdoor stationary air samples were also collected to monitor for potential releases of contaminated materials during scenario-related activities. For Scenario 4, the stationary air monitors were placed in four locations surrounding the perimeter of the rototilling activity.

Real-time Aerosol Monitors

For Scenarios 2 and 3, HazDust^{TM} real-time aerosol monitors (RAMs) were used to quantify the level of dust particles in indoor air before, during, and after the scenario-related activities. This included both personal and stationary samples. Filters from these RAM monitors were also analyzed for asbestos in the same manner as the personal and stationary filters. For the purposes of this report, all samples obtained from a HazDust^{TM} RAM are designated "HazDust", while all other samples collected from personal or stationary monitors are identified without this designation.

Collection Timing

For each of the activity-based scenarios, samples that were collected can be categorized into three general time intervals: pre-activity, during activity, and post-activity. In general, the samples of greatest interest are those collected during the activity, since these provide data on the level of LA in air associated with the activity. Stationary samples collected before or after the activity were used mainly to establish a frame of reference for evaluating the sample collected during the activity. Personal air samples collected before and after the various activities were mainly intended for the purposes of ensuring worker protection, and may not be representative of air concentrations likely to be inhaled by residents. Thus, these samples were not evaluated further in this assessment.

2.3   Collection of Source Materials

Each of the four scenarios in Phase 2 was designed to investigate the potential for release of asbestos fibers into air by disturbance of some potential source material (indoor dust, vermiculite insulation, soil). To obtain preliminary information on the relationship between the concentration of asbestos in a source material and the concentration that may result in air when the source is disturbed, samples of indoor dust, vermiculite insulation, and garden soil were

collected prior to the commencement of scenario-related activities. Table 2-4 summarizes the source material samples collected for each scenario.

3.0   SAMPLING METHODS

The detailed methods and Standard Operating Procedures (SOPs) used to collect samples of air and potential source media are provided in the Phase 2 QAPP (USEPA 2001). As noted previously, the study design and collection methods were optimized as necessary in the field based on input from the Libby field sample collection teams and with oversight and approval from USEPA. Appendix A provides the field modification forms which document study modifications and deviations. Brief summaries of the sampling methods used in the Phase 2 study are presented below.

3.1   Air

Personal and Stationary Air Monitors

All personal and stationary air samples to be analyzed for asbestos were collected by drawing air through a mixed cellulose ester (MCE) filter in accord with SOP EPA-LIBBY 01 (USEPA 2001). Samples collected using a high-volume pump (primarily the stationary air samples) employed filters that had pores 0.45 um in diameter. Personal air samples were usually collected using a low volume pump and filters with 0.8 um diameter pores. The Phase 2 QAPP (USEPA 2001) specified target volumes for each type of stationary and personal air sample collected to ensure adequate analytical sensitivities. Table 3-1 summarizes the typical volumes achieved for air samples collected during each scenario. As seen, with the exception of Scenario 1 and personal samples from Scenario 2, most air samples achieved the target air volumes. Samples that do not achieve the target volume have decreased sensitivity and may be associated with increased uncertainty in concentration values, but do not otherwise diminish the value of the samples.

Real-time Aerosol Monitors

Airborne dust levels were measured using a real-time aerosol monitor (RAM) in accord SOP EPA-LIBBY-03 (USEPA 2001). Two types of measurements were obtained from the RAMs. First, continuous measurements of airborne dust levels (mg/m^3) were acquired at one-second intervals prior to the activity, during the activity, and at one or more times following the activity. These measures of airborne dust are referred to as RAM dust levels in this report. Second, filters placed within the RAM were analyzed for asbestos in the same manner as personal and stationary filters. These concentrations of asbestos in air derived from RAM filters will be referred to as HazDust asbestos concentrations in this report. Due to the variability in air flow rates through HazDust filters, confidence in estimates of asbestos concentrations in air is low for HazDust samples compared to the asbestos concentrations from stationary and personal air monitors. Because of this, Hazdust asbestos concentrations were only used in an evaluation of the correlation between dust and LA levels in air, and were not used to estimate human exposure or risk.

3.2   Dust

Dust samples were collected on 0.45 um pore MCE filters using a microvacuum method, similar to that detailed in ASTM 5755-95 (ASTM 1995), as modified for this project (USEPA 2001). Dust samples were collected at most of the residences in which routine and active cleaning activities (Scenarios 1 and 2) were investigated. Dust samples were also collected before and

after carpet removal activities (Scenario 3C). Surficial dust samples were composite samples collected from two to four different indoor locations (each location area consisting of 100 cm^2). Dust sampling locations included both surfaces (e.g., window sills, shelves) where dust may settle out, as well as floors (e.g., entryways, living areas).

If cleaning activities resulted in the generation of a visible pile of dust or dirt, a sample of this material was also collected using the microvacuum technique. These samples are referred to as "dust pile" samples. Because neither the total area swept nor the total dust mass generated was recorded for these dust pile samples, it is not possible to use the results to calculate either an asbestos loading (s/cm^2) or a concentration (s/g) for these samples. Therefore, samples identified as dust piles were not evaluated in this report.

3.3   Vermiculite Insulation

For several residences participating in the Phase 2 study, vermiculite insulation samples had been collected previously as part of other investigations and additional sample collection was not necessary. If bulk insulation samples were not available for a residence, samples were collected as part of the Phase 2 study. In most instances, the insulation was collected from several locations at different depths in order to obtain a representative sample of the insulation. All insulation samples were collected in accordance with NIOSH Method 9002 (NIOSH 1994b).

3.4   Garden Soil

As part of previous investigations, two surface soil samples had been collected from the garden selected for rototilling. Therefore, no additional soil samples were collected from this area as part of the Phase 2 study.

3.5   Sample Documentation, Handling and Custody Requirement

Data on the type, location, collection method and collection time of all samples were recorded both in a field log book maintained by the field sampling team and on a sample data entry sheet designed to facilitate data entry into the site database (see Section 3.6 below). Hard copies of all field data sheets and field log books generated during the Phase 2 study are stored at CDM field office in Libby and at Volpe (available upon request). All samples collected in the field were maintained under chain of custody during sample handling, preparation, shipment, and analysis.

3.6   Data Management

All information on locations and samples collected, analyses performed, and raw analytical results are stored and maintained in a site database (referred to as the Libby2DB) housed on a SQL server in Research Triangle Park. Raw data for all Phase 2 samples for use in this report were downloaded into a Microsoft Access® database by SRC on January 23, 2006. A copy of the Phase 2 Access database is provided in Appendix B of this report (provided electronically on the attached CD). Any changes made to the Libby2DB since this download will not be reflected in the current Phase 2 Access database[2].

---

[2] For several samples, the Libby2DB did not provide adequate descriptions for the purposes of data evaluation. The field sample data sheets and field activity logs were used to address these data limitations. Proposed changes to the sample descriptor fields in the Libby2DB are pending review.

4.0   SAMPLE PREPARATION AND ANALYSIS METHODS

The detailed analytical methods used to prepare and analyze samples of air, dust, insulation, and soil are provided in the Phase 2 QAPP (USEPA 2001), and are summarized below.

In some instances, problems or errors occurred in the analysis of individual samples, and these are documented in sample-specific laboratory modifications forms prepared by the analytical laboratory. These forms are available from Volpe upon request.

4.1   Air and Dust

Sample Preparation

All air samples collected during this study were prepared for direct examination by PCM in accord with the procedure specified in NIOSH 7400, and samples were prepared for TEM examination in accord with the method specified in ISO 10312. When reliable fiber counts could not be obtained for one or both methods due to excessive particle loading on the filter, an indirect preparation was made and the indirect preparation was re-analyzed by both methods. All dust samples were prepared for TEM analysis using the indirect preparation method.

Counting Rules

For PCM, the counting rules established by NIOSH 7400 (NIOSH, 1994a) were used for all air samples. Differential counting (i.e., excluding fibers which the analyst suspects are not asbestos) was not employed because, as noted in NIOSH 7400, there is no presently-accepted method for ensuring uniformity of judgment between analytical laboratories.

For TEM, most air and dust samples were analyzed using ISO 10312 (International Organization for Standardization, 1995) counting rules, modified for site-specific purposes to require recording of structures shorter than 0.5 um and also structures with an aspect ratio less than 5:1.

Air clearance samples were analyzed by TEM in accord with the counting rules specified in the Asbestos Hazardous Emergency Response Act of 1986 (the AHERA method). These analyses were performed by the on-site field laboratory in order to shorten the analytical turn-around time. This was necessary since the results from these samples were required to ensure that levels in the home were safe before allowing the residents to return.

Fiber Mineral Classes

When a sample is analyzed by TEM, individual asbestos structures are observed, and their size, shape, and mineral type are recorded. Mineral type was assessed using Selected Area Electron Diffraction (SAED) and Energy Dispersive Spectroscopy (EDS), and each structure was assigned to one of the following four categories:

>   LA   Libby-class amphibole. Structures having an amphibole SAED pattern and an
>   elemental composition similar to the range of fiber types observed in ores from
>   the Libby mine (USGS 2001). This is a sodic tremolitic solid solution series of

minerals including actinolite, tremolite, winchite, and richterite, with lower amounts of magnesio-arfedsonite and edenite/ferro-edenite.

OA　　Other amphibole-type asbestos fibers. Structures having an amphibole SAED pattern and an elemental composition that is not similar to fibers types from the Libby mine. Examples include crocidolite, amosite, and anthophyllite. There is presently no evidence that these fibers are associated with the Libby mine.

C　　Chrysotile fibers. Structures having a serpentine SAED pattern and an elemental composition characteristic of chrysotile. There is presently no evidence that these fibers are associated with the Libby mine.

NAM　　Non-asbestos material. These may include non-asbestos mineral fibers such as gypsum, glass, or clay, and may also include various types of organic and synthetic fibers derived from carpets, hair, etc.

4.2　Vermiculite Insulation

Vermiculite insulation samples were evaluated for asbestos content using Polarized Light Microscopy (PLM), in accord with NIOSH 9002. Results (expressed as area percent) were reported either as Non-Detect (asbestos is not present at levels observable by PLM), Trace (asbestos is present but at a level too low [<1%] to be reliably quantified by PLM), or Detect (asbestos is present and a reliable estimate of the area percent [>1%] can be made).

4.3　Garden Soil

As noted previously, no garden soil samples were collected as part of Phase 2 study. However, two soil samples from the rototilled garden had previously been collected and analyzed by PLM in accord with NIOSH 9002. As noted above, PLM results from NIOSH 9002 are reported as either Non-Detect, Trace, or Detect.

5.0   QUALITY CONTROL

A number of Quality Control (QC) samples were collected during this project to help characterize the accuracy and precision of the data obtained. QC samples included both field-based samples (which are submitted blind to the laboratories) and laboratory-based samples.

5.1   Field-Based QC Samples

In the Phase 2 study, two types of field-based QC samples were collected and submitted to the laboratories:

> Field Blank (FB) – This is a filter cassette for either a personal or a stationary air monitor or a microvacuum, but through which no air is drawn. Most field blank samples for air are prepared for analysis using a direct preparation, while field blank samples for dust are prepared using an indirect preparation. As specified in the Phase 2 QAPP (USEPA 2001), the target rate for air and dust field blank collection was 5%. There is no field blank for soil or insulation.

> Field Duplicate (FD) or Field Replicate (FR[3]) – These are repeat samples of environmental medium collected at the same place and at the same time as the primary sample. In the Phase 2 study, only field replicates/duplicates for air and dust were collected. As specified in the Phase 2 QAPP (USEPA 2001), the target rate for field replicates of air was 5%. No target rates were specified for dust, since there are no criteria to judge whether the agreement between samples is within some pre-defined acceptance limit. Duplicate samples of dust were collected only to gain an initial understanding of the degree of inter-sample variability.

Performance Evaluation (PE) standards (samples with known levels of asbestos contamination) were not employed because no suitable certified standards were located for amphibole fibers in air, soil, or insulation at the time of the Phase 2 study.

Results for Field Blanks

Table 5-1 summarizes the analytical results of the PCM and TEM field blanks. As seen, 134 PCM field blank samples and 197 TEM field blank samples[4] were collected as part of the Phase 2 study. Field blanks for PCM and TEM were collected and analyzed at a rate of about 30%. These rates are well above the target rate specified in the Phase 2 QAPP (5%).

For PCM, the average loading across all air field blanks was 0.24 s/mm^2. For TEM, the average loading of LA structures was 0.024 s/mm^2 and 0.28 s/mm^2 for air field blanks and dust field

---

[3] The Phase 2 Project Plan (USEPA 2001) identified the code for Field Replicate samples as "REP". The code was changed to "FR" in the Libby 2 Database, which utilizes a two-letter abbreviation.

[4] As noted in Table 5-1, results from one TEM field blank (2-00164) were excluded from this evaluation because it is suspected that this sample was inadvertently an analysis of a field dust sample rather than an authentic field blank. This suspicion is based on the observation that the number of chrysotile structures observed in this sample were similar to counts for two field dust samples collected by the same team at the same property on the same day (N = 16 chrysotile structures), and a second field blank collected at the same time indicates no chrysotile structures were observed. Because only chrysotile structures were observed in this field blank, even if it were retained, it would have no impact on the interpretation of LA loading on field blank filters.

blanks, respectively.   A description of how PCM and TEM field blank data were utilized in the interpretation of analytical results for field samples is presented in Section 6.1.

Results for Field Replicates/Duplicates

Field replicates of air were collected at a rate of approximately 3% (12 field replicates / 374 stationary air field samples). While this rate is lower than the target rate (5%) specified in the Phase 2 QAPP, the number of sample pairs (12) is nevertheless adequate to assess the degree of agreement, and this deviation form the QAPP does not significantly impair the assessment of data quality.

A total of 3 duplicate surficial dust samples were collected from locations immediately adjacent to the original dust sampling locations. As noted above, there was no specified number or rate for collection of dust duplicates, and these samples were intended only to provide an initial assessment of variability in dust samples.

Appendix C provides a detailed summary of the TEM and PCM analytical results for each field replicate/duplicate sample, and the results are summarized in Table 5-2. For each pair, the concentration estimates derived from the original and replicate samples were compared using the method for comparison of two Poisson rates described by Nelson (1982).

For air samples analyzed by TEM (upper panel), none of the 12 of the pairs were statistically different. Likewise, for dust analyzed by TEM (middle panel), none of the three pairs were statistically different. For air samples analyzed by PCM (bottom panel), 8 of the 9 pairs were not statistically different from each other, while one pair was significantly different ($p < 0.05$). Figure 5-1 provides a graphical presentation of these PCM data. The dotted line represents the line of identity (the line on which all data would fall if both results were the same). As seen, with the exception of the one data pair, agreement is good between the PCM replicates. The reason for the difference between the original and replicate sample for this one pair is not known, but the overall degree of agreement for air samples is 20/21 (95%), which is consistent with the conclusion that air sample results collected during Phase 2 are reliable.

5.2   Laboratory-Based QC Samples

The following types of QC sample analyses were performed by each of the participating analytical laboratories:

> Recount Same (RS) – This is a TEM grid that is re-examined by the same microscopist who performed the initial examination. The microscopist returns to the same grid openings as were counted in the original examination.

> Recount Different (RD) – This is a TEM grid that is re-examined by a different microscopist than who performed the initial examination. The microscopist returns to the same grid openings as were counted in the original examination.

> Verified Analysis (VA) – This is a recount of a TEM grid (same grid openings) performed in accord with the protocol for verified analysis as provided in NIST (1994).

> Repreparation (RP) – This is a grid that is prepared from a new aliquot of the same field sample as was used to prepare the original grid. Typically this is done within the same

lab as did the original analysis, but a different lab may also prepare grids from a new piece of filter. If the re-preparation is done within a laboratory, the re-preparation and re-analysis should be done by a different person than did the original, whenever possible.

At the time of the Phase 2 QAPP preparation, no quantitative rules had been established for evaluating the results of re-analysis or re-preparation samples. Since then, Libby Laboratory Modification LB-00029a (USEPA 2003) identified program-wide goals for the interpretation of laboratory-based QC samples for TEM re-analyses. The criteria established in LB-00029a are used here to assess the within-laboratory QC samples performed during the Phase 2 investigation.

Appendix D presents the results for each type of laboratory-based QC sample, and the results are summarized below.

Recount (RS, RD, VA) Samples

For recount same (RS), recount different (RD) and verified analyses (VA), comparisons to the original analysis were evaluated on a grid opening-by-grid opening and structure-by-structure basis. Only those grid openings that were able to be re-examined were included in this evaluation. As specified in the LB-00029a, there are three metrics that were evaluated to assess the degree of agreement (concordance) for LA particles between re-analyses:

Total Number of LA Structures – For grid openings with 10 or fewer structures, total LA structure counts must match exactly to be considered concordant. For grid openings with more than 10 LA structures, counts must be within 10% to rank as concordant.

Mineral Class – There must be 100% agreement on mineral type (chrysotile vs. amphibole) to be considered concordant. Within the amphibole assignment, there must be at least 90% agreement on the assignment of LA and OA to be considered concordant.

LA Structure Dimensions – Structure dimension concordance was evaluated for LA structures only. For LA fibers and bundles, structure length and width must be within 0.5 um or 10% (whichever is less stringent) to be ranked as concordant. For LA clusters and matrices, structure length must be within 1 um or 20% (which ever is less stringent) to be ranked as concordant. There are no rules for width concordance for clusters and matrices.

Program-wide assessment of overall concordance rates for recount samples are as follows:

Metric	Program-Wide Assessment		
	Good	Acceptable	Poor
Concordance on LA count	>95%	85-95%	<85%
Concordance on asbestos type	>99%	95%-99%	<95%
Concordance on LA length	>90%	80%-90%	<80%
Concordance on LA width	>90%	80%-90%	<80%

In accord with the Phase 2 QAPP, recounts were performed at a rate of approximately 5% (58 out of 1207). These 58 recounts consisted of 44 RS[5], 3 RD, and 11 VA analyses. In these 58 recounts, a total of 699 grid openings (GOs) were re-analyzed. About 99.6% (694 of 699) of all GOs evaluated were non-detect for LA in both the original analysis and the recount[6]. One or more LA structures were seen in the original and/or recount in only five GOs. The results for these five GOs are summarized in Table 5-3.

As seen, 3 of the 5 GOs were ranked as discordant based on differences in the total number of LA structures. When the same structures were observed, the reanalysis was always in agreement on mineral class assignment and reported width, and was in agreement for 2 of 3 LA structure for reported length. For the one LA structure in which the reported length was ranked as discordant, the length was reported as 9 um in the original analysis and 10.7 um in the reanalysis.

When discrepancies were identified between the original and the recount analyses, the senior analyst for the laboratory determined the basis of the discordance and took appropriate corrective action (e.g., re-training in counting rules, quantification of size, identification of types, etc).   Each laboratory maintains records of all cases of discordant results and of actions taken to address any problems.

Because structures were observed in so few grid openings during recounts in the Phase 2 study, it is not possible to draw reliable conclusions about the degree of concordance from these results. Summary statistics for the entire program through the present time are provided in (USEPA, 2006), and these data provide a better basis for drawing conclusions regarding the degree of concordance between recount samples. As noted in footnote 5, the strategy for selecting samples for recounting has also been changed to emphasize samples that have a higher frequency of grids with one or more LA structures, and this will help improve understanding in the degree of concordance as more samples are evaluated in the future.

Re-preparation (RP)

As specified in LB-00029a, re-preparation samples are compared to each other using the method for statistical comparison of two Poisson rates (Nelson 1982). The overall goal is that no more than 5% of all re-preparations yield results that are statistically different.

In the Phase 2 study, re-preparations were performed at a rate of about 2% (19 out of 1207). While this rate is lower than the target rate (5%) specified in the Phase 2 QAPP, the number of re-preparation samples (19) is adequate to draw reliable conclusions about the degree of agreement.

Of the 19 re-preparation samples, 15 were from air samples and 4 were from dust samples. In 17 out of the 19 re-preparation samples, the total number of structures observed in both the

---

[5] The results from 3 RS analyses were excluded from this evaluation because the grid openings evaluated in the RS analysis were different than those evaluated in the original analysis.

[6] The high frequency of grid opening with no LA structures is a consequence of the fact that samples were selected for recounting before the results of the first analysis were available. Because recounting of grid openings with zero structures present is not very informative, the procedure has subsequently been modified to select samples for re-count after the original result is obtained, which allows for preferential recounting of samples with structures present in one or more grids.

original analysis and the re-preparation was zero[7]. For the two re-preparation analyses in which one or more structures were observed, the original analysis result and the re-preparation result were not statistically different from each other. Thus, overall agreement for re-preparation samples was 19/19 (100%).

5.3   Overall Conclusions Regarding Data Quality

As described in the sections above, the QC samples collected and analyzed as discussed above indicate that the data quality for the samples collected as part of the Phase 2 study is generally good. The evaluation of field blanks show that data collection methods did not introduce contamination. Replicate samples of field air samples showed that results were generally reproducible by both TEM and PCM, and dust field duplicates show that there is limited inter-sample variability between samples collected in close proximity. Re-counting of selected grid openings indicate that some differences may exist between microscopists in the recognition and classification of fibers, but the data are too limited to draw a meaningful conclusion on the magnitude or significance of any inter-analyst variability. Re-preparation and re-analysis of air and dust samples by TEM showed good reproducibility, indicating that differences between grids from the same air or dust filter due to preparation methods are likely to be minor. Based on these QC findings, all data collected during the Phase 2 program are considered to be reliable and appropriate for use without qualification.

---

[7] Similar to the case for recounting samples discussed above, the procedure for selection of re-preparation samples has been altered to prioritize samples that have detectable levels of LA, and this will help provide more meaningful results in the future.

6.0   DATA REDUCTION

Raw data for all Phase 2 samples are available in Appendix B of this report (provided in a Microsoft Access® database on the attached CD). Methods employed in the calculation of concentration and loading values from these data are summarized below.

Combining Results from Multiple TEM Analyses of a Single Sample

In some instances, the same air or dust sample was analyzed more than one time by TEM. In most cases, the second analysis simply evaluated additional GOs to improve analytical sensitivity for the sample. Therefore, in the Phase 2 study, if an air or dust sample was analyzed more than once by TEM, each analysis result was combined together to represent a single "pooled" result value that collapses across all TEM analyses. As discussed in Technical Memorandum 11 (USEPA 2005b), the pooled result was calculated as follows:

$$\text{Pooled Result} = \sum N_i / \sum TAE_i$$

where:

N_i = Number of structures for analysis 'i' that meet the specified grouping rules (e.g., $PCMEasb$, $PCME_{LA}$, Total LA, $BCPS_{LA}$)

TAE_i = Total Amount Evaluated for analysis 'i'
For air: TAE (cc) = 1/Air Sensitivity (1/cc)
For dust: TAE (cm^2) = 1/Dust Sensitivity ($1/cm^2$)

Assigning Detect/Non-Detect Status

In order for a field sample to be ranked as a detect, the number of structures counted in the field sample must be higher than the 95th percentile of the range of counts that would be expected to come from background based on field blank results (ASTM 2001). This evaluation is performed as follows:

- Given a mean field blank loading rate of λ_0 (f/mm^2) (see Table 3-1), the mean number of background structures (μ_0) that would be expected during an examination of an area A is:

$$\mu_0 \text{ (structures)} = \lambda_0 \cdot \text{Total Area (A) of field sample examined } (mm^2)$$

Note that the value of A (and hence the value of μ_0) can vary from sample to sample.

- Based on μ_0, the Poisson distribution is used to find the number (count) of background structures (*x0*) that would be observed in no more than 5% of a set of random observations of an area A in field blanks.

- If the number of structures (N) counted in the field sample is greater than *x0*, the field sample is ranked as a detect. If N is less than or equal to *x0*, the observed number of

structures in the field sample could be attributable to background and the sample is ranked as a non-detect.

Note that for PCM samples, the NIOSH Method 7400 identifies 7 f/mm^2 (5.5 structures in a typical analysis of 100 fields of view) as the cutoff for distinguishing detects from non-detects. However, based on site-specific data (see Table 3-1), the value of λ_0 for PCM is 0.24 s/mm^2, which corresponds to a value of μ_0 of 0.19 structures (assuming analysis of 100 fields of view), which corresponds to a value of 1 for *x0*. Thus, any PCM sample with more than 1 structure was ranked as a detect in this report.

For TEM, site-specific data for air field blanks show that the value of λ_0 for LA by TEM is 0.029 s/mm^2 (see Table 3-1). The value of μ_0 will depend upon the total number of grid openings evaluated and the grid opening size, both of which are analysis-specific. For example, in an analysis of 20 grid openings with a grid opening size of 0.01 mm^2, μ_0 would be equal to 0.006 LA structures, which corresponds to a value of 0 for *x0*. Thus, in this example, if 1 LA structure is observed, the TEM analysis ranks as a detect.

Calculation of Concentration Values for Detects

Once a sample is classified as a detect, the concentration of air concentration or dust loading of asbestos structures is given as:

Air Concentration (f/cc) or Dust Loading (f/cm^2) = N $\cdot$ S

where:

N = Number of structures observed
S = Sensitivity (1/cc for air or 1/cm^2 for dust)

The calculation of the sample sensitivity depends upon the media analyzed (air or dust). For air, the sensitivity is calculated as:

$$S = \frac{A_f}{GO \cdot A_{go} \cdot V \cdot 1000 \cdot F}$$

where:

S = Sensitivity in air (1/cc)
A_f = Effective area of the filter (mm^2)
GO = Number of grid openings examined
A_{go} = Area of a grid opening (mm^2)
V = Volume of air passed through the filter (L)
1000 = Conversion factor (cc/L)
F = Fraction of primary filter deposited on secondary filter (indirect preparation only)

For dust, the sensitivity is calculated as:

$$S = \frac{A_f}{GO \cdot A_{go} \cdot SA \cdot F}$$

where:

       S = Sensitivity in dust ($1/cm^2$)
       N = Number of structures observed
       A_f = Effective area of the filter (mm^2)
       GO = Number of grid openings examined
       A_{go} = Area of a grid opening (mm^2)
       SA = Area vacuumed during sampling (cm^2)
       F = Fraction of primary filter deposited on secondary filter

Note that this calculation does not include a correction to account for the potential contribution of structures from background. This is because, in this investigation, the contribution is small (see Table 3-1), and subtraction of an estimated contribution from background could lead to an underestimate of the true concentration in some cases.

Evaluation of Non-Detects in Summary Statistics

USEPA guidance for exposure and risk calculations at Superfund sites recommends that non-detects typically be evaluated by assuming a concentration value equal to ½ the detection limit. However, as described in Technical Memorandum 11 (USEPA, 2005b), because the sensitivity (S) reported for an asbestos analysis in is not analogous to a detection limit (LOD), if an asbestos non-detect is assigned a value equal to ½ the analytical sensitivity, the estimate of the mean will be biased high unless the sensitivity is very low and the frequency of non-detects is low. Only when non-detects are evaluated by using a value of zero is the sample mean a reliable estimate of the true mean. Therefore, in this report, when computing summary statistics across a group of samples, all non-detects were evaluated by assuming a value of zero.

Estimating Upper and Lower Confidence Bounds on Individual Samples

The uncertainty around any PCM or TEM estimate of asbestos concentration in a sample is a function of the number of structures observed during the analysis. The 90% confidence interval around any observed number of structures is given by the Poisson distribution:

       5% LB = 0.5 · CHIINV[0.95, (2 · N)]
       95% UB = 0.5 · CHIINV[0.05, (2 · N+2)]

where:

       CHIINV = Inverse chi-squared cumulative distribution function
       N = Number of structures observed

As illustrated in Table 6-1, as N increases, the absolute width of the confidence interval increases, but the relative uncertainty [expressed as the 90% confidence interval (CI) divided by the observed value (N)] decreases.

The basic equation for calculation of the upper and lower bounds on the air concentration or dust loading of asbestos structures is given as:

Air Concentration (f/cc) or Dust Loading (f/cm^2) = (LB or UB) $\cdot$ S

where:

LB or UB = Number of structures based on lower bound (LB) or upper bound (UB)
S = Sensitivity (1/cc for air or 1/cm^2 for dust)

Estimating Upper and Lower Confidence Bounds on Summary Statistics

The calculation of confidence bounds across multiple samples is more complicated because both sampling variability (i.e., differences between samples within a location due to random variation) and measurement error contribute to the overall variability. In this report, a screening level approach was used to calculate the LB and UB across multiple samples within the same location. In this approach, the LB on the mean was set equal to the mean of the sample-specific LBs, and the UB on the mean was set equal to the mean of the sample-specific UBs. This simplified approach is likely to overestimate the true confidence bounds.

Sub-Categories of PCME Fibers

When a sample is analyzed by PCM, it is not possible to reliably distinguish between asbestos and non-asbestos particles, or between asbestos particles that are LA and those that are other types of asbestos. However, when samples are analyzed by TEM, it is readily possible to distinguish between asbestos and non-asbestos, and also between LA and other asbestos types. Therefore, for the purposes of comparing PCM results to TEM results, TEM fibers were classified according to the following definitions:

- PCME: This includes all fibers detected by TEM that are equivalent to those that would have been detected using PCM. PCM fibers are equal to or longer than 5um, have an aspect ratio (length:width) of at least 3:1, and are thick enough to be detected by PCM (about 0.25 um in diameter). Note that this will include particles that are not asbestos, as well as all types of asbestos (LA, other amphiboles, chrysotile).

- PCME$_{asb}$: This includes all PCME structures that are asbestos, and excludes all other organic and inorganic particles that are not asbestos.

- PCME$_{LA}$: This includes all PCME structures that are asbestos, and are of the LA type. It excludes any asbestos fibers (chrysotile, other amphiboles) that are not believed to be associated with the Libby mine site.

7.0 RESULTS

Raw data for all Phase 2 samples are available in Appendix B of this report (provided in a Microsoft Access® database on the attached CD). Appendix E includes a summary of the TEM, PCM, and PLM results for all field samples utilized in the Phase 2 study. This appendix is grouped by Scenario (1-4), media type (air personal, air stationary, dust, bulk insulation, soil), sample collection timing (pre/during/post-activity, clearance), and sample type (e.g., HazDust).

7.1 Objective 1: Comparison of Personal vs. Stationary Air Samples

The first objective of the Phase 2 study was to determine if there was a significant difference in the levels of fibers measured in air when the sample was collected in the breathing zone of a person engaged in some activity (personal air samples) compared to a stationary monitor located in the vicinity of the activity.

For the purposes of this evaluation, personal samples were restricted to full period samples (i.e., excursion samples were excluded), because the full period personal samples had collection periods which coincided with the paired stationary samples. If more than one personal or stationary sample was collected from a property (i.e., two individuals participated in the activity or stationary monitors were placed in multiple rooms/floors), the mean air concentration across samples within the same residence was used. Table 7-1 summarizes the by-sample results for all personal and stationary air samples included in this evaluation.

Table 7-2 provides summary statistics for personal and stationary air samples, grouped by analytical method, concentration metric, and activity scenario, as well as information on the ratio of personal vs stationary air values. The ratio between personal and stationary air samples was calculated using two different methods. The first method calculated the ratio for each scenario based on the individual paired data point ratios, and then calculated the mean ratio across all pairs. This method only included pairs for which both samples were detect. The second method calculated the mean concentration of all personal samples and the mean concentration of all stationary samples for each scenario, and then utilized these mean concentrations to estimate the mean ratio.

As seen in Table 7-2, the air concentrations for personal air monitors tend to be higher than air concentrations for stationary air monitors in all scenarios for nearly all concentration metrics (e.g., PCM, $PCME_{asb}$, $PCME_{LA}$, Total LA). In general, ratios between personal and stationary samples tend to be lowest (closer to 1) for Scenario 1 (routine activities) and highest for Scenario 4 (rototilling activities).

Figure 7-1 (TEM $PCME_{LA}$) and Figure 7-2 (PCM) plots the paired data points (i.e., mean personal vs. mean stationary), stratified by activity scenario. Each data point includes bars that show the 90% confidence interval. For reference, each graph also includes a line of identity (the line on which all data would fall if both measures were the same and there were no measurement error). These figures illustrate that paired data points tend to fall below the line of identity, meaning that personal air concentrations tend to be higher than stationary air concentrations. While this difference is seen for both TEM and PCM, it is most apparent for air concentrations analyzed by PCM (Figure 7-2).

Table 7-3 summarizes the results from the statistical comparison of the personal and stationary air concentrations (based on the statistical method in Nelson, 1982). As seen, depending upon the concentration metric evaluated, statistically significant differences between personal and stationary samples were seen at one or more properties for all scenarios. In general, when differences were statistically significant, the personal air concentrations were usually higher than the stationary air concentrations.

This evaluation supports the conclusion that stationary air monitors may tend to underestimate exposure and risk of individuals who engage in activities that disturb asbestos-containing source material. The magnitude of the underestimation depends upon the scenario; scenarios that are associated with routine activities and minimal disturbances (e.g., Scenario 1) are associated with only small differences (ratios close to 1), while scenarios that are associated with active disturbances (e.g., Scenarios 3 and 4) are associated with the greatest differences (ratios above 1). The absolute magnitude of the difference between a pair of stationary and personal samples is expected to be highly variable between different settings, depending on the intensity and duration of disturbance activities, the nature of the source material, the speed and direction of wind or air flow in the vicinity, and the distance between the activity and the stationary monitor.

7.2   Objective 2: Comparison of PCM and TEM Results

The second objective of the Phase 2 study was to analyze a series of different air samples by both the TEM and PCM methods in order to help judge which type of measurement is most reliable and appropriate in determining asbestos levels in air. In particular, the goal was to address two questions related to differences between PCM and TEM:

1) Does PCM overestimate asbestos concentrations relative to TEM, because PCM does not distinguish between asbestos and non-asbestos fibers in a sample?

2) Does PCM underestimate asbestos concentrations relative to TEM, because PCM can not visualize structures thinner than about 0.25 um in thickness and does not include structures shorter than 5 um?

For the purposes of this evaluation, air samples were restricted to those which had been analyzed by both PCM and TEM. Table 7-4 summarizes the by-sample results for all PCM and TEM analyses included in this evaluation.

The first question was assessed by comparing PCM air concentrations to TEM PCMEasb air concentrations. These results are shown in Figure 7-3. Each data point includes bars that show the 90% confidence interval for each air sample result. For reference, each graph includes a line of identity (the line on which all data would fall if both measures were the same and there were no measurement error). A tabular summary at the bottom of this figure provides summary statistics for air samples from each activity scenario for PCMEasb and PCM.

The ratio between PCMEasb and PCM air samples was calculated using two different methods. The first method calculated the ratio for each scenario based on the individual paired data point ratios, and then calculated the mean ratio across all pairs. This method only included pairs for which both samples were detect. The second method calculated the mean concentration of all TEM samples and the mean concentration of all PCM samples for each scenario, and then utilized these mean concentrations to estimate the mean ratio.

21

As seen in Figure 7-3, paired data points tend to fall above the line of identity, meaning that PCM air concentrations tend to be higher than PCMEasb air concentrations. In general, PCM air concentrations are between 3-5 times higher than TEM PCMEasb air concentrations. These differences are most apparent in Scenarios 1 (routine activities) and 2 (active cleaning activities). This is probably because samples in a residential setting are likely to contain non-asbestos particles such as carpet fibers, pet hair, etc. These non-asbestos fibers would be counted in the PCM method, but excluded from counts in PCMEasb. In Scenario 3, there is a somewhat clearer (but still weak) correlation between PCMEasb and PCM. Scenario 3 measurements were usually taken in an enclosed work area in which vermiculite insulation was actively disturbed, so it is likely that the majority of particles collected on filters were asbestos, rather than other types of household fibers as in Scenarios 1 and 2.

The second question was evaluated by determining the fraction of all TEM LA structures in air that are thinner than 0.25 um and/or shorter than 5 um. Figure 7-4 presents a summary of the length and width measurements for all LA structures observed in TEM analyses for air samples collected from the Libby site, and the percentage of the total fibers in each category are presented below:

Length	Width		
	< 0.25 um	≥ 0.25 um	Total
≤ 5 um	19%	32%	50%
> 5 um	5%	45%	50%
Total	23%	77%	100%

As seen, about 23% all LA structures are thinner than 0.25 um, and about 50% are shorter than 5 um. Taken together, structures that would have been counted by PCM (or PCME) constitute about 45% of the total LA structures counted by TEM.

This evaluation supports the conclusion that use of PCM will usually tend to overestimate exposure of individuals who engage in activities that disturb asbestos-containing source material, especially in residential environments, since a number of non-asbestos fibers will be included. Conversely, use of PCM will tend to underestimate exposure to total LA, since about 55% of all LA structures are either too thin or too short to count by PCM. Because the relationship between PCM and TEM varies with the setting of the activity, the type of source material, and the location of the air monitor, it is not possible to establish a default site-specific relationship between the two methods.

7.3   Objective 3: Screening Level Estimation of Potential Health Risk

Exceedences of OSHA Standards

The Occupational Safety and Health Administration (OSHA) has established two occupational standards for exposure of workers – an 8-hour time-weighted average (TWA) value of 0.1 PCM fibers/cc, and a short-term exposure limit (STEL) of 1 PCM fibers/cc.

For the purposes of evaluating air samples collected during Phase 2 the STEL was used to evaluate all short-term "excursion" samples (these were generally about 30 minutes in duration), and the OSHA TWA standard was used as a frame of reference for all "full period" samples. It should be noted that some of the "full period" samples did not represent a full 8 hours, but only spanned a time interval of two hours or so. However, that is only because the activity ceased at

that time, and the measured concentration values from the full period samples are assumed to be applicable to cases where the activity extended for longer time periods.

As shown in Table 7-5, a number of personal air samples collected during Phase 2 scenario activities exceeded the TWA (upper panel) or the STEL (lower panel), especially for active cleaning (Scenario 2) and active disturbance of vermiculite (Scenario 3) activities. In considering these results, it is important to recognize that occupational exposure standards for asbestos are not generally applicable to (and may not be protective of) residents or workers in non-asbestos environments. This is because occupational standards are intended to protect individuals who a) are fully aware of the hazards of the occupational environment, b) have specific training and access to protective equipment such as respirators and/or protective clothing and, c) actively participate in medical monitoring (USEPA 1995). None of these conditions apply to residents or to workers at typical commercial establishments. Thus, simple compliance with the OSHA standards is not evidence that exposure levels are acceptable in a home or in a non-asbestos workplace. Indeed, levels of concern for residents or workers may occur at exposure levels substantially below the OSHA workplace standards, as discussed below.

Initial Cancer Risk Estimates

EPA has developed a methodology for estimating cancer risks from inhalation exposure to asbestos (USEPA 1986, IRIS 2006).   In this approach, the concentration of asbestos in air is expressed in terms of PCM (or PCME) structures/cc, where the definition of a PCM(E) structure is any structure that has a length > 5 um, an aspect ratio (length/width) ≥ 3:1, and a thickness ≥ 0.25 um.   One potential limitation to this method is that the PCM analytical method does not distinguish between amphibole and chrysotile structures. However, data have accumulated over the last 10-15 years that suggest amphiboles tend to be more potent that chrysotile, so application of the IRIS model at a site such as Libby where amphiboles are of chief concern might tend to underestimate the true risk. The EPA is presently working to develop and validate a refined risk assessment methodology that helps to account for differing potency between amphibole and chrysotile asbestos (USEPA 2003), but the method is not yet approved for quantitative use at Superfund sites.

Because of the current uncertainties in the most appropriate approach for estimating excess cancer risks from asbestos, risk estimates are not presented here, but will be included in the baseline human health risk assessment for the site.

7.4   Relationships Between Sources, Activities, and Exposures

Asbestos fibers that are present in a source material do not pose a health hazard to humans unless the source material is disturbed in a way that asbestos fibers are released to air. Thus, the concentration of fibers in air depends on two main variables: the concentration in the source, and the nature (intensity, duration) of the disturbing force acting on the source. In general, the relationship between the concentration in air and the concentration in a source may be expressed as a "K-factor", as follows:

$$C(air) / C(source) = K \text{ factor}$$

Although the Phase 2 study did not specifically seek to obtain data that would allow development of robust site-specific K factors, the available data were evaluated to determine if

23

they could provide initial screening level information on likely values and ranges of K factors for varying scenarios. Emphasis was placed on personal rather than stationary air samples, since these are believed to provide the most relevant measure of airborne concentration level for each scenario.

Dust to Air Transfer

The relationship between the concentration of structures in air (s/cc) and the asbestos loading in dust (s/cm^2) may be expressed as a ratio:

$$Kda\ (cm^2/cc) = Cair\ (s/cc)\ /\ Ldust\ (s/cm^2)$$

The value of Kda is expected to be highly variable, depending on the nature of the forces that disturb the dust and cause the fibers to become resuspended. Thus, it is appropriate to consider that there are a series of Kda values, depending on the forces acting on the dust. Using data collected as part of the Phase 2 study, two basic types of Kda factors can be estimated for a residential setting:

1) The "baseline" value (Scenario 1) that applies under routine household conditions. The forces that lead to dust resuspension include thermal air currents, mechanical vibrations, and "routine" human or pet movements and activities.

2) The "active disturbance" values that apply when dust is being disturbed by an activity such as active cleaning (Scenario 2A), beating cushions (Scenario 2B), or removing carpets (Scenario 3C).

Table 7-6 presents a summary, grouped by property, of all the personal air results for samples collected during Scenario 1 and the dust results for samples collected prior to the commencement of any Scenario 2-related activities. Table 7-7 presents a summary, grouped by property, of all the personal (full period) air results collected during Scenario 2A, 2B, and 3C activities and the dust results for samples collected prior to the commencement of any active disturbance activities. As seen, while asbestos was detected in air or dust at several locations, there was only one case where asbestos was detected in both air and dust for any activity scenario. Because of this, it is not possible to calculate meaningful site-specific Kda values using the limited data available from the Phase 2 study.

Bulk Insulation or Soil to Air Transfer

Bulk insulation or soil can also be a potential source material for asbestos when these bulk materials are disturbed causing a release of asbestos fibers into the air, such as in Scenario 3 (e.g., active disturbance of attic insulation) or Scenario 4 (rototilling garden soil). Table 7-8 presents asbestos levels in bulk insulation and soil as well as the corresponding air concentrations measured during scenario-related disturbances of vermiculite and soil. However, because concentrations in the source material are estimated by PLM and are reported in semi-quantitative bins, it is not possible to compute quantitative transfer factors for releases from these media.

7.5   Correlation Between Airborne Dust and Asbestos

As noted above, real-time aerosol monitors (RAMs) were used to measure the concentration of dust in air during Scenarios 2 and 3, and particles in the air passing through the RAMs was also collected on filters for subsequent evaluation for LA. Figure 7-5 provides an example of the RAM output for dust in air collected during active cleaning activities (Scenario 2A). As seen, observed dust levels varied widely depending upon activity type and location within the residence. For each activity, the mean dust level was calculated by averaging the recorded dust levels across the entire sampling duration.

Figure 7-6 presents a plot of the paired RAM dust levels and corresponding levels of LA in air measured by TEM Total LA on the HazDust filters. Of the 143 filters examined, LA particles were observed in only 11 cases, and the correlation between RAM dust levels and asbestos levels in air is weak (R^2 = 0.14). This weak relationship between airborne dust levels and airborne LA levels is most likely a consequence of the limited analytical sensitivity of most HazDust filter analyses for LA (mean TEM sensitivity = 0.05 cc^{-1}), coupled with a high degree of variability in LA content in dust. Thus, the results should not be interpreted as evidence that disturbance of dust is not a potentially important source of LA in indoor air in Libby.

8.0   CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

The data resulting from the Phase 2 study indicate the following main conclusions:

- Analysis of air and dust samples by PCM will generally tend to over-estimate exposure to $PCME_{LA}$, especially in the residential setting. This is because a number of structures are counted by PCM that are neither asbestos nor LA. This problem is probably less significant in occupational settings where other types of fibers are less common, but may still occur in some cases. In addition, it is apparent that PCM captures only a subset of the total LA fibers in air, with a substantial fraction being either shorter than 5 um and/or thinner than 0.25 um. Thus, total exposure to LA will usually be underestimated by PCM. Thus, analysis of air and dust samples by TEM, while slower and more costly than PCM, will generally provide more reliable and more complete data on actual exposure levels to LA.

- Evaluation of exposure using stationary air samplers will usually tend to underestimate exposure compared to personal air samplers. The magnitude of the underestimation is variable, tending to be smallest for routine exposures, and highest for scenarios that are associated with active disturbances of source materials. Thus, personal air samples are generally preferred. However, it is also important to consider that use of personal air samplers is often inconvenient, and that the analytical sensitivity of personal air samples is often lower than for stationary samplers. Thus, the choice between stationary and personal air sampling for any particular exposure scenario must balance these opposing factors.

- In general, the levels of LA in air tend to be highly variable over time and space. This emphasizes the need to collect additional data on the levels of LA that occur in association with a wide range of activities and at a wide range of locations in order to better understand the exposures and risks which may be occurring at the site.

- Concentration values in most samples of air and dust are in a range where TEM analysis based on only 10-20 grid openings is likely to identify only a relatively small number of LA particles. Because there is high analytical uncertainty associated with a small number of detected particles, future sampling efforts should seek to increase the number of grid opening evaluated to the extent allowed by time and cost constraints. This will increase sensitivity and decrease uncertainty in concentration, exposure, and risk estimates.

- The data collected during Phase 2 were not adequate to derive any meaningful estimates of transfer factors for LA from soil to outdoor air, soil to indoor dust, or indoor dust to indoor air. This is mainly because of the high variability in soil, dust, and air values, coupled with a relatively low analytical sensitivity and a resultant high frequency of non-detects for most Phase 2 samples. Future efforts to derive data adequate to estimate transfer factors will require increased analytical sensitivity and an increased numbers of paired samples in order to increase the utility of the data.

9.0   REFERENCES

Asbestos Hazardous Emergency Response Act (AHERA). 1986. Title 20, Chapter 52, Sec. 4011. Public Law 99-519.

Amandus, H.E., and Wheeler, R. 1987. The morbidity and mortality of vermiculite miners and millers exposed to tremolite-actinolite: Part II. Mortality. *Am. J. of Ind Med.* 11:15-26.

Amandus, H.E. Wheeler, P.E., Jankovic, J., and Tucker, J. 1987a. The morbidity and mortality of vermiculite miners and millers exposed to tremolite-actinolite: Part I. Exposure estimates. *Am J Ind. Med* 11:1-14.

Amandus, H.E., Althouse, R., Morgan, W.K.C., Sargent, E.N., and Jones, R. 1987b. The morbidity and mortality of vermiculite miners and millers exposed to tremolite-actinolite: Part III. Radiographic findings. *Am. J. Ind. Med* 11:27-37.

ASTM. 1995. Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations. ASTM D 5755-95. American Society for Testing and Materials. October 1995.

ASTM. 2001. Standard Practice for Asbestos Detection Limit Based on Counts. ASTM D6620-00. American Society for Testing and Materials. Current edition approved December 10, 2000. Published March 2001.

ATSDR. 2000. Health Consultation: Mortality from asbestosis in Libby, Montana. CERCLIS No. MT0009083840. December 12, 2000. DHHS, ATSDR, DHAC; Atlanta, GA.

ATSDR. 2001. Preliminary findings of medical testing of individuals potentially exposed to asbestiform minerals associated with vermiculite in Libby, Montana: an interim report for community health planning. February 22, 2001. DHHS, ATSDR; Atlanta, GA.

ATSDR. 2002a. Mortality in Libby, Montana, 1979-1998. ATSDR Health   Consultation. Atlanta, GA: Agency for Toxic Substances and Disease Registry.

ATSDR. 2002b. Review of Asbestos-Related Abnormalities Among a Group of Patients from Libby, Montana. A Pilot Study of Environmental Cases. June 21, 2002. Atlanta, GA: Agency for Toxic Substances and Disease Registry.

Berman DW, and Crump, K. 2003. Technical Support Document for a Protocol to Assess Asbestos-Related Risk. Prepared for the USEPA Office of Solid Waste and Emergency Response, EPA #9345.4-06 October 2003.

International Organization for Standardization. 1995. Ambient Air – Determination of asbestos fibres – Direct-transfer transmission electron microscopy method. ISO 10312:1995(E).

IRIS. 2006. Download form EPA's Integrated Risk Information System (IRIS), available at http://www.epa.gov/iriswebp/iris/index.html

McDonald, J.C., McDonald, A.D., Armstrong, B, Sebastien. 1986. Cohort study of mortality of vermiculite miners exposed to tremolite. *British Journal of Ind. Med. 43:436-444.*

Nelson W. 1982. Applied Life Data Analysis. John Wiley & Sons, New York. pp 438-446.

NIOSH. 1994a. Asbestos and Other Fibers by PCM. NIOSH 7400 (Issue 2). August 15,1994.

NIOSH. 1994b. Asbestos (bulk) by PCM. NIOSH 9002 (Issue 2). August 15, 1994.

NIST. 1994. Airborne Asbestos Method: Standard Test Method for Verified Analysis of Asbestos by Transmission Electron Microscopy - Version 2.0.   SOP prepared by S. Turner and E.B. Steel, U.S. Department of Commerce, National Institute of Standards and Technology. NIST IR 5351. March 1994.

USEPA. 1986. Airborne Asbestos Health Assessment Update EPA/8-84/003F June 1986.

USEPA. 1995. Regional Technical Position Paper on the Proper use of Occupational Health Standards for Superfund Baseline Risk Assessments. February 13, 1995.

USEPA. 2000. Sampling and Quality Assurance Project Plan (Revision 1) for Libby, MT. Prepared by USEPA Region 8 with technical support from ISSI Consulting Group.

USEPA. 2001. Phase 2 Sampling and Quality Assurance Project Plan (Revision 0) for Libby, Montana. Environmental Monitoring for Asbestos. *Evaluation of Exposure to Airborne Asbestos Fibers During Routine and Special Activities.* March 2001.

USEPA. 2003. Request for Modification to Laboratory Activities LB-00029a, November 2003.

USEPA. 2005a. Supplemental Remedial Investigation Quality Assurance Project Plan for Libby, Montana (Revision 1). August 5, 2005.

USEPA. 2005b. DRAFT - Technical Memorandum 11: Procedure for Combining TEM Results Across Different Counting Rules and Sample Preparation Methods. December 12, 2005.

USEPA. 2006. DRAFT - Quality Assurance and Quality Control (QA/QC) Summary Report for Libby, Montana. *In preparation*.

USGS. 2001. The chemical composition and physical properties of amphibole from Libby, Montana: A progress report. Meeker, G.P., Brownfield, I.K., Clark, R.N., Vance, J.S., Hoefen, T.M., Sutley, S.J., Gent, C.A., Plumlee, G.S., Swayze, G., Hinkley, T.K., Horton, R., and Ziegler, T. Poster presented at the USEPA Health Effects of Asbestos Conference, May 24-25, 2001, Oakland CA. United States Geological Survey, Denver Federal Center, Denver CO.

TABLES

Table 2-1
Properties Participating in the Phase 2 Study

Property ID	Phase 2 Scenarios Evaluated at this Property	VCI in Attic?	VCI PLM LA AF%	Phase 1 Air/Dust Results
B	1,2A,3B,3E	Yes	<1%	no LA detected
D	1,2A	Yes	<1%	LA detected
E	2A,2B,3C	Yes		LA detected
F	2A	Yes	2%	LA detected
G	1,2A	No		LA detected
I	2A	No		LA detected
J	2A	Unknown		LA detected
M	1,2A	Yes	<1%	no LA detected
N	1,2A,3C	No		no samples
O	1,2A	No		no LA detected
P	2A	Yes	<1%	LA detected
Q	1,2A	Yes		LA detected
R	1	Yes (a)	<1%	no LA detected
S	1	No		no samples
T	1,2A	Yes		LA detected
U	1,2A	Yes (a)	<1%	LA detected
X	1,2A	Yes (a)		LA detected
Y	1,2A	Yes		LA detected
Z	4	No		no LA detected
AA	1,2A	Yes		no LA detected
AB	1	Yes		no samples
AC	1,2A	No		no LA detected
K (A&L)	3A,3B,3D			
A (Unit 1)	2A,3C,3E	Yes	<1%	LA detected
L (Unit 2)	3A,3B,3D,3E			
C (V&W)	3E			
V (Unit 1)	2A	Yes	<1%	LA detected
W (Unit 2)	2A			

(a) garage attic only

Phase 2 Scenarios:
  Scenario 1: Routine Activities
  Scenario 2: Cleaning Activities
      2A: Sweeping, dusting, vacuuming
      2B: Beating sofa cushions
  Scenario 3: Active Disturbance of Vermiculite
      3A: Sweeping or moving debris/insulation in attic
      3B: Cutting holes into ceilings or walls
      3C: Replacing or removing carpeting
      3D: Removing vermiculite via hand-bagging
      3E: Removing vermiculite via vacuum truck
  Scenario 4: Rototilling

Table 2-2 Phase 2 Study Air Sampling Design

Scenario	Sample Type	Sample Collection Timing		
		Pre	During	Post
1 - Routine Activities	Personal Air		x	
	Stationary Air (main house)		x	
2 - Active Cleaning	Personal Air (work area)		x	
	Personal RAM (work area)		x	
	Stationary Air (main house)	x	x	x
	Stationary RAM (work area)	x	x	x
	Stationary RAM (main house)	x	x	x
3 - Active Disturbance of Vermiculite	Personal Air (work area)		x	
	Personal RAM (work area)		x	
	Stationary Air (work area)	x	x	x
	Stationary Air (main house)	x	x	x
	Stationary RAM (work area)	x	x	x
	Stationary RAM (main house)	x	x	x
4 - Garden Rototilling	Personal Air (work area)		x	
	Stationary Air (perimeter)	x	x	x

RAM - Real-Time Aerosol Monitor

Table 2-2_Study Design.xls, 3/29/2006

Table 2-3 Phase 2 Air Samples

Scenario	Matrix	Sample Type	Collection Timing	Number of samples collected[a]
1: Routine Activities	Air, Indoor	Personal, Full Period	during	16
		Stationary	during	26
2: Active Cleaning	Air, Indoor	Personal, Full Period	during	42
			post (decon)	35
		Personal, Excursion	during	78
			post (decon)	36
		Stationary	pre	35
			during	33
			post	14
			clearance	35
	Air, Outdoor	Personal, Full Period	during	2
		Personal, Excursion	during	1
		Stationary	during	1
3: Vermiculite Disturbance	Air, Indoor	Personal, Full Period	pre (staging)	4
			during	21
			post (decon)	6
		Personal, Excursion	pre (staging)	2
			during	37
			post (decon)	6
		Stationary	pre	7
			during	12
			post	10
			clearance	25
	Air, Outdoor	Stationary	during	40
4: Rototilling	Air, Outdoor	Personal, Full Period	during	2
		Personal, Excursion	during	3
		Stationary	pre	4
			during	4
			post	4

[a] Includes only field samples, excludes HazDust samples

Table 2-3&2-4_Sample Summary v2.xls, 3/29/2006

Table 2-4 Phase 2 Source Material Samples

Scenario	Medium	Collection Timing	Number of samples collected[a]
2: Active Cleaning	Surficial dust composite	pre	17
		post	17
	Dust pile	post	6
3: Carpet Removal	Surficial dust composite	pre	2
		post	2
3: Vermiculite Disturbance	Attic insulation	pre	10
4: Rototilling	Surface soil composite (0-4 in.)	pre	0[b]

[a] Includes only field samples

[b] Two samples collected during Phase 1 sampling activities

Table 2-3&2-4_Sample Summary v2.xls, 3/29/2006

Table 3-1
Comparison of Target Air Volumes to Achieved Air Volumes
for Samples Collected for TEM Analysis

Scenario	Sample Type	Collection Timing	Target Volume (L)	Achieved Volume (L)	
				Mean	Range
1: Routine Activities	Personal	During	>80,000	4,983	4,585 - 5,344
	Stationary	During	>80,000	4,994	4,547 - 5,475
2: Cleaning Activities	Personal	During	690	184	50 - 402
	Stationary	Pre/During/Post	690	1,106	106 - 2,166
3: Active Disturbance of Vermiculite	Personal	During	14	131	5 - 499
	Stationary	During	400	826	43 - 1,926
	Stationary	Pre/Post	1,200	1,453	92 - 1,914
4: Rototilling	Personal	During	70	69	42 - 107
	Stationary	During	70	336	328 - 342
	Stationary	Pre/Post	1,200	1,285	1,216 - 1,350

Target volumes for TEM analysis, as reported in Appendix G of the Phase 2 QAPP (USEPA, 2001).

Table 5-1
Field Blank Results

Parameter	PCM (Air)	TEM		
		Air	Dust	Air+Dust
N Field Blanks	134	172	25[a]	197
N Field Samples	453	542	46	588
% of all Phase 2 samples that were field blanks	*30%*	*32%*	*54%*	*34%*
Total Area Examined (mm^2)	143	41	4	45
Total Number of Structures	25	1	4	5
Libby Amphibole (LA)	--	1	1	2
Other Amphibole (OA)	--	0	0	0
Chrysotile (C)	--	0	3	3
Blank Filter Loading (s/mm^2)				
Total	0.24	0.024	1.1	0.11
Libby Amphibole (LA)	--	0.024	0.28	0.045
Other Amphibole (OA)	--	0	0	0
Chrysotile (C)	--	0	0.85	0.067

-- = not applicable; PCM cannot determine asbestos from non-asbestos
[a] Excludes results for one TEM field blank (sample ID 2-00164).

Table 5-2
Comparison of Air Concentrations and Dust Loadings in
Original and Replicate Samples Analyzed by TEM and PCM

Indoor Air Results, TEM Total LA

	Original Result			Replicate Result				
ID	N LA Structures	Conc (s/cc)	90% Poisson CI	ID	N LA Structures	Conc (s/cc)	90% Poisson CI	p value (a)
2-00709	0	0.0E+00	0.0E+00 - 6.6E-03	2-00711	0	0.0E+00	0.0E+00 - 6.6E-03	Both ND
2-00809	0	0.0E+00	0.0E+00 - 1.2E-02	2-00810	0	0.0E+00	0.0E+00 - 1.2E-02	Both ND
2-00669	3	2.9E-01	7.9E-02 - 7.5E-01	2-00671	0	0.0E+00	0.0E+00 - 2.9E-01	0.083
2-00659	0	0.0E+00	0.0E+00 - 4.1E-03	2-00662	0	0.0E+00	0.0E+00 - 2.7E-03	Both ND
2-00633	0	0.0E+00	0.0E+00 - 4.7E-02	2-00636	0	0.0E+00	0.0E+00 - 4.7E-02	Both ND
2-00619	0	0.0E+00	0.0E+00 - 3.3E-03	2-00622	0	0.0E+00	0.0E+00 - 2.2E-03	Both ND
2-00516	0	0.0E+00	0.0E+00 - 3.5E-03	2-00518	1	9.3E-04	4.8E-05 - 4.4E-03	0.26
2-00526	0	0.0E+00	0.0E+00 - 3.7E-03	2-00528	1	7.9E-04	4.0E-05 - 3.7E-03	0.38
2-00466	0	0.0E+00	0.0E+00 - 4.0E-01	2-00467	0	0.0E+00	0.0E+00 - 4.0E-01	Both ND
2-00478	0	0.0E+00	0.0E+00 - 4.5E-02	2-00479	0	0.0E+00	0.0E+00 - 4.5E-02	Both ND
2-00249	0	0.0E+00	0.0E+00 - 1.5E-03	2-00250	1	5.1E-04	2.6E-05 - 2.4E-03	0.32
2-00157	0	0.0E+00	0.0E+00 - 1.6E-03	2-00158	0	0.0E+00	0.0E+00 - 7.3E-04	Both ND

Surficial Dust Results, TEM Total LA

	Original Result			Replicate Result				
ID	N LA Structures	Loading (s/cm²)	90% Poisson CI	ID	N LA Structures	Loading (s/cm²)	90% Poisson CI	p value (a)
2-00678	0	0.0E+00	0.0E+00 - 1.7E+03	2-00679	0	0.0E+00	0.0E+00 - 1.7E+03	Both ND
2-00627	0	0.0E+00	0.0E+00 - 1.7E+03	2-00628	0	0.0E+00	0.0E+00 - 1.7E+03	Both ND
2-00473	0	0.0E+00	0.0E+00 - 5.8E+01	2-00474	0	0.0E+00	0.0E+00 - 1.7E+03	Both ND

Indoor Air Results, PCM

	Original Result			Replicate Result				
ID	N LA Structures	Conc (s/cc)	90% Poisson CI	ID	N LA Structures	Conc (s/cc)	90% Poisson CI	p value (a)
2-00809	5	2.0E-03	8.0E-04 - 4.3E-03	2-00810	2	8.2E-04	1.4E-04 - 2.6E-03	Both ND
2-00669	0	0.0E+00	0.0E+00 - 2.2E-02	2-00671	0	0.0E+00	0.0E+00 - 2.2E-02	Both ND
2-00659	1	4.1E-04	2.1E-05 - 1.9E-03	2-00662	3	1.2E-03	3.3E-04 - 3.2E-03	Both ND
2-00633	15	1.8E-02	1.1E-02 - 2.8E-02	2-00636	17	2.1E-02	1.3E-02 - 3.1E-02	Both ND
2-00619	3	1.0E-03	2.7E-04 - 2.6E-03	2-00622	2	6.7E-04	1.2E-04 - 2.1E-03	Both ND
2-00466	35	3.6E-01	2.7E-01 - 4.8E-01	2-00467	4	4.2E-02	1.4E-02 - 9.5E-02	<0.0001
2-00478	6	6.9E-03	3.0E-03 - 1.4E-02	2-00479	10	1.2E-02	6.3E-03 - 2.0E-02	Both ND
2-00249	53	5.3E-03	4.1E-03 - 6.6E-03	2-00250	56	5.6E-03	4.4E-03 - 6.9E-03	Both ND
2-00157	56	5.7E-03	4.5E-03 - 7.1E-03	2-00158	56	5.7E-03	4.5E-03 - 7.1E-03	Both ND

(a) Nelson (1982)

[grey shading] statistically different (p <0.05)

Table 5-3
Concordance Results for Grid Openings with One or More LA Structures Observed

Index ID	Medium	Prep	Analysis	Grid	GO	Structure Count			Structure	Mineral Class			LA Length			LA Width		
						Original	Reanalysis	C ?		Original	Reanalysis	C ?	Original	Reanalysis	C ?	Original	Reanalysis	C ?
2-01084	Air	Direct	ISO	1	A-8	2	2	Yes	1	LA	LA	Yes	1.5	1.4	Yes	0.2	0.22	Yes
									2	LA	LA	Yes	9.0	10.7	No	0.4	0.35	Yes
				1	H-3	1	1	Yes	3	LA	LA	Yes	2.2	2.4	Yes	0.3	0.3	Yes
				1	N-8	1	0	No	4	LA	--	--	30	--	--	1.8	--	--
2-01181	Air	Direct	ISO	2	J-14	0	1	No	1	--	LA	--	--	4.6	--	--	1	--
2-01196	Air	Direct	ISO	1	L-2	0	1	No	1	--	LA	--	--	6.4	--	--	0.8	--

Concordance rate: 40%   100%   67%   100%

Table 6-1
Poisson Confidence Intervals

N	LB	UB	CI	CI / N
0	0.00	3.00	3.00	+Infinity
1	0.05	4.74	4.69	469%
2	0.36	6.30	5.94	297%
3	0.82	7.75	6.94	231%
5	1.97	10.51	8.54	171%
10	5.43	16.96	11.54	115%
20	13.25	29.06	15.81	79%
50	38.96	63.29	24.32	49%

N = Number of structures
LB = Lower Bound on N
UB = Upper Bound on N
CI = Confidence Interval Width (UB-LB)
CI/N = Relative Uncertainty

Table 7-1
Summary of Air Samples Utilized in the Personal vs. Stationary Evaluation
Scenario 1: Routine Activities

Property ID	Personal Air Monitor Samples (a)						Stationary Air Monitor Samples (a)						
	Index ID	TEM Air Conc (b) (s/cc)	90% Poisson CI		PCM Air Conc (s/cc)	90% Poisson CI		Index ID	Monitor Location	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI
T	2-00001	0E+00	0E+00 -	2E-03				2-00002	1st Floor	0E+00	0E+00 - 2E-03		
								2-00003	2nd Floor	0E+00	0E+00 - 2E-03		
AC	2-00004	0E+00	0E+00 -	2E-03				2-00005	Kitchen	0E+00	0E+00 - 2E-03		
D	2-00018	5E-04	4E-04 -	1E-03	0E+00	0E+00 -	3E-04	2-00019	Downstairs	0E+00	0E+00 - 8E-04	9E-03	8E-03 - 1E-02
								2-00020	Upstairs	3E-04	3E-04 - 1E-03	5E-03	4E-03 - 6E-03
								2-00021	Main Level	5E-04	4E-04 - 1E-03	8E-03	7E-03 - 1E-02
Q	2-00022	1E-03	7E-04 -	1E-03	0E+00	0E+00 -	3E-04	2-00023	Living room	8E-04	6E-04 - 1E-03	0E+00	0E+00 - 3E-04
O	2-00026	0E+00	0E+00 -	4E-03	1E-02	1E-02 -	2E-02	2-00027	Living room	0E+00	0E+00 - 4E-03	1E-02	1E-02 - 1E-02
Y	2-00030	0E+00	0E+00 -	2E-03	4E-03	3E-03 -	5E-03	2-00031	Main level	0E+00	0E+00 - 2E-03	5E-03	4E-03 - 6E-03
								2-00032	Upstairs	1E-03	1E-03 - 3E-03	5E-03	4E-03 - 7E-03
R	2-00035	0E+00	0E+00 -	8E-04				2-00036	Main level	3E-04	2E-04 - 1E-03	4E-03	3E-03 - 5E-03
								2-00037	Downstairs	3E-04	3E-04 - 1E-03	3E-03	2E-03 - 4E-03
X	2-00040	0E+00	0E+00 -	7E-04	1E-02	9E-03 -	1E-02	2-00041	Hallway	0E+00	0E+00 - 7E-04	8E-03	7E-03 - 1E-02
U	2-00044	0E+00	0E+00 -	9E-04	4E-03	3E-03 -	5E-03	2-00045	Living room	0E+00	0E+00 - 9E-04	4E-03	3E-03 - 6E-03
								2-00046	Upstairs	0E+00	0E+00 - 9E-04	5E-03	4E-03 - 6E-03
AA	2-00071	0E+00	0E+00 -	2E-03				2-00072	Main Level	0E+00	0E+00 - 8E-04	4E-03	3E-03 - 5E-03
								2-00073	Upstairs	0E+00	0E+00 - 8E-04	2E-03	1E-03 - 3E-03
AB	2-00076	0E+00	0E+00 -	8E-04	2E-03	1E-03 -	2E-03	2-00077	Hall/Living room	0E+00	0E+00 - 8E-04	2E-03	1E-03 - 2E-03
B	2-00080	0E+00	0E+00 -	8E-04				2-00081	Main level	0E+00	0E+00 - 8E-04	2E-03	2E-03 - 3E-03
								2-00082	Downstairs	0E+00	0E+00 - 2E-03	6E-04	3E-04 - 1E-03
N	2-00155	0E+00	0E+00 -	2E-03	2E-02	4E-03 -	4E-02	2-00156	Main level	5E-04	5E-04 - 2E-03	1E-02	1E-02 - 1E-02
								2-00157	Downstairs	0E+00	0E+00 - 2E-03	6E-03	4E-03 - 7E-03
M	2-00165	0E+00	0E+00 -	6E-04	2E-02	4E-03 -	4E-02	2-00166	Living room	0E+00	0E+00 - 1E-03	4E-03	3E-03 - 6E-03
G	2-00247	2E-03	1E-03 -	3E-03	8E-03	6E-03 -	9E-03	2-00248	Upstairs	5E-04	5E-04 - 2E-03	6E-03	5E-03 - 8E-03
								2-00249	Basement	0E+00	0E+00 - 2E-03	5E-03	4E-03 - 7E-03
S	2-01041	0E+00	0E+00 -	4E-03	1E-03	7E-04 -	2E-03	2-01042	Main level	0E+00	0E+00 - 4E-03	1E-03	1E-03 - 2E-03

(a) Includes air samples collected during scenario activities.

(b) TEM air concentrations based on PCMEla

Table 7-1
Summary of Air Samples Utilized in the Personal vs. Stationary Evaluation
Scenario 2: Active Cleaning Activities

Property ID	Personal Air Monitor Samples (a)						Stationary Air Monitor Samples (a)					
	Index ID	Activity Type	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI	Index ID	Monitor Location	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI
J	2-00921	2A	0E+00	0E+00 - 2E-02	3E-02	2E-02 - 4E-02	2-00912	Downstairs	0E+00	0E+00 - 5E-02	2E-02	9E-03 - 3E-02
							2-00911	Main level	0E+00	0E+00 - 5E-02	5E-03	2E-03 - 1E-02
B	2-00341	2A	0E+00	0E+00 - 5E-02	5E-02	4E-02 - 6E-02	2-00323	Main level	0E+00	0E+00 - 4E-02	2E-02	1E-02 - 3E-02
	2-00344	2A	0E+00	0E+00 - 5E-02	3E-02	2E-02 - 4E-02	2-00324	Downstairs	0E+00	0E+00 - 5E-02	4E-03	1E-03 - 9E-03
AA	2-00537	2A	0E+00	0E+00 - 1E-02	3E-02	2E-02 - 4E-02	2-00524	Upstairs	0E+00	0E+00 - 2E-02		
	2-00542	2A	3E-03	3E-03 - 1E-02	4E-02	3E-02 - 6E-02	2-00523	Main level	0E+00	0E+00 - 0E+00		
M	2-00874	2A	0E+00	0E+00 - 2E-02	2E-02	1E-02 - 3E-02	2-00867	Living room	0E+00	0E+00 - 5E-02	2E-02	1E-02 - 3E-02
	2-00878	2A	0E+00	0E+00 - 2E-02	3E-02	2E-02 - 4E-02						
AC	2-00408	2A	0E+00	0E+00 - 3E-01	3E-01	2E-01 - 4E-01	2-00398	Kitchen	0E+00	0E+00 - 2E-02	2E-02	9E-03 - 3E-02
	2-00411	2A	0E+00	0E+00 - 6E-02	4E-02	3E-02 - 6E-02						
O	2-01062	2A	0E+00	0E+00 - 7E-03	3E-02	2E-02 - 5E-02	2-01055	Living room	0E+00	0E+00 - 2E-02	7E-03	3E-03 - 1E-02
	2-01066	2A	0E+00	0E+00 - 7E-03	3E-02	2E-02 - 5E-02						
P	2-00793	2A	0E+00	0E+00 - 1E+00	3E-01	2E-01 - 6E-01	2-00478	Living room	0E+00	0E+00 - 4E-02	7E-03	3E-03 - 1E-02
	2-00797	2A	0E+00	0E+00 - 2E-02	1E-02	8E-03 - 2E-02						
D (barn)	2-00186	2A	0E+00	0E+00 - 4E-01			2-00171	Barn	4E-03	3E-03 - 9E-03		
	2-00188	2A	0E+00	0E+00 - 7E-02	8E-02	6E-02 - 1E-01						
D (main house)	2-00240	2A	0E+00	0E+00 - 5E-02	3E-02	2E-02 - 4E-02	2-00220	Upstairs	3E-03	3E-03 - 1E-02	1E-02	8E-03 - 2E-02
	2-00243	2A	0E+00	0E+00 - 5E-02	2E-02	1E-02 - 3E-02	2-00222	Downstairs	3E-03	3E-03 - 1E-02	2E-02	9E-03 - 2E-02
							2-00224	Main level	7E-03	5E-03 - 1E-02	1E-02	7E-03 - 2E-02
Q	2-00209	2A	0E+00	0E+00 - 8E-02	7E-02	5E-02 - 1E-01	2-00194	Living room	0E+00	0E+00 - 7E-03	2E-02	1E-02 - 3E-02
	2-00211	2A	0E+00	0E+00 - 8E-02	4E-02	3E-02 - 6E-02						
F	2-00379	2A	0E+00	0E+00 - 3E-01	1E+00	7E-01 - 1E+00	2-00361	Main level	0E+00	0E+00 - 5E-02	7E-02	5E-02 - 9E-02
	2-00382	2A	0E+00	0E+00 - 5E-02	7E-02	6E-02 - 9E-02	2-00362	Basement	0E+00	0E+00 - 5E-02	2E-02	1E-02 - 3E-02
E (barn)	2-00090	2A	0E+00	0E+00 - 9E-01			2-00098	Barn	0E+00	0E+00 - 2E-02		
	2-00091	2A	0E+00	0E+00 - 9E-01								
E (main house)	2-00975	2A	0E+00	0E+00 - 2E-02	4E-02	3E-02 - 6E-02	2-00968	Living room	0E+00	0E+00 - 1E+00	1E+00	8E-01 - 2E+00
	2-00979	2A	0E+00	0E+00 - 1E+00	1E-01	8E-02 - 1E-01						
	2-01344	2B	0E+00	0E+00 - 5E-02			2-01341	outdoors	0E+00	0E+00 - 2E-01		
T	2-00443	2A	0E+00	0E+00 - 6E-02	4E-02	3E-02 - 6E-02	2-00429	1st floor	0E+00	0E+00 - 4E-02	6E-03	2E-03 - 1E-02
	2-00446	2A	0E+00	0E+00 - 6E-02	6E-02	5E-02 - 8E-02	2-00430	2nd floor	0E+00	0E+00 - 4E-02	8E-03	4E-03 - 1E-02
U	2-00300	2A	2E-02	2E-02 - 8E-02	3E-02	2E-02 - 4E-02	2-00282	Living room	6E-03	6E-03 - 2E-02	1E-02	5E-03 - 2E-02
	2-00302	2A	0E+00	0E+00 - 6E-02	2E-02	1E-02 - 3E-02	2-00283	Upstairs	0E+00	0E+00 - 2E-02	1E-02	7E-03 - 2E-02
C	2-00149	2A	0E+00	0E+00 - 1E-02	0E+00	0E+00 - 5E-03	2-00135	Upstairs	0E+00	0E+00 - 1E-02		
	2-00152	2A	0E+00	0E+00 - 1E-02	0E+00	0E+00 - 5E-03						
V	2-00114	2A	8E-03	7E-03 - 2E-02	2E-01	1E-01 - 2E-01	2-00108	Kitchen	6E-03	5E-03 - 1E-02		
G	2-00642	2A	5E-03	4E-03 - 1E-02	2E-02	1E-02 - 3E-02	2-00632	Upstairs	0E+00	0E+00 - 5E-02	2E-02	1E-02 - 3E-02
	2-00646	2A	7E-03	5E-03 - 1E-02	1E-02	8E-03 - 2E-02	2-00633	Basement	0E+00	0E+00 - 5E-02	2E-02	1E-02 - 3E-02
X (garage)	2-00834	2A	0E+00	0E+00 - 2E+00	4E-01	2E-01 - 8E-01	2-00828	Garage	0E+00	0E+00 - 2E-02	1E-01	4E-02 - 3E-01
	2-00839	2A	0E+00	0E+00 - 2E+00	6E-01	3E-01 - 9E-01						
X (main house)	2-00273	2A	0E+00	0E+00 - 6E-02	3E-02	2E-02 - 4E-02	2-00258	Hallway	0E+00	0E+00 - 1E-02	3E-02	2E-02 - 4E-02
	2-00275	2A	0E+00	0E+00 - 6E-02	6E-02	4E-02 - 8E-02						
Y	2-00499	2A	0E+00	0E+00 - 3E+00	6E-01	3E-01 - 1E+00	2-00485	Main level	0E+00	0E+00 - 9E-02		
	2-00502	2A	0E+00	0E+00 - 2E+00	2E-01	5E-02 - 5E-01	2-00487	Upstairs	0E+00	0E+00 - 9E-02		
I	2-01231	2A	0E+00	0E+00 - 7E-03	9E-02	7E-02 - 1E-01	2-01223	1st floor	0E+00	0E+00 - 4E-02		
	2-01236	2A	0E+00	0E+00 - 2E-02	9E-02	8E-02 - 1E-01	2-01224	2nd floor	0E+00	0E+00 - 4E-02		

(a) 2A: Full period indoor air samples, collected during scenario activities (excludes decon samples).
  2B: Full period outdoor air samples, collected during scenario activities (excludes decon samples).
(b) TEM air concentrations based on PCMEIa

2A: Sweeping, dusting, vacuuming
2B: Beating sofa cushions

Table 7-1
Summary of Air Samples Utilized in the Personal vs. Stationary Evaluation
Scenario 3: Active Disturbance of Vermiculite

Property ID	Personal Air Monitor Samples (a)						Stationary Air Monitor Samples (a)					
	Index ID	Activity Type	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI	Index ID	Monitor Location	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI
B	2-01133	3E	8E-01	3E-01 - 4E-01	1E+00	7E-01 - 1E+00	2-01137	Living room/hallway	0E+00	0E+00 - 2E-03	2E-03	1E-03 - 4E-03
	2-01027	3B	7E-01	5E-01 - 1E+00	2E+00	1E+00 - 2E+00	2-01004	Kitchen	8E-01	3E-01 - 4E-01	3E-01	2E-01 - 3E-01
							2-01024	Bathroom	0E+00	0E+00 - 3E-02	2E-02	6E-03 - 6E-02
L	2-00739	3A/B	2E-01	1E-01 - 2E-01	3E-01	2E-01 - 4E-01	2-00732	Work area	0E+00	0E+00 - 4E-01	3E-01	2E-01 - 4E-01
	2-00744	3A/B	8E-02	6E-02 - 2E-01	1E-01	7E-02 - 2E-01	2-00733	Living area	0E+00	0E+00 - 4E-01	1E-01	8E-02 - 2E-01
E	2-01278	3C	9E-02	8E-02 - 2E-01	1E-02	7E-03 - 2E-02	2-01272	Living room	0E+00	0E+00 - 1E+00		
	2-01282	3C	0E+00	0E+00 - 3E-01	1E-02	7E-03 - 2E-02	2-01273	Master bedroom	0E+00	0E+00 - 1E+00		
K	2-00572	3A/B	3E-01	1E-01 - 2E-01	3E-01	2E-01 - 4E-01	2-00566	Attic	1E-01	5E-02 - 8E-02	7E-02	5E-02 - 1E-01
	2-00588	3A/B	2E-02	2E-02 - 9E-02	6E-02	2E-02 - 1E-01	2-00567	Living room	2E-02	2E-02 - 4E-02	4E-02	2E-02 - 6E-02
N	2-00693	3C	0E+00	0E+00 - 1E-02	2E-02	1E-02 - 3E-02	2-00683	Living room - main level	0E+00	0E+00 - 4E-02	1E-02	8E-03 - 2E-02
	2-00697	3C	4E-03	4E-03 - 2E-02	4E-02	3E-02 - 5E-02	2-00685	Living room - main level	0E+00	0E+00 - 4E-02	3E-02	2E-02 - 4E-02
A	2-00058	3C	0E+00	0E+00 - 2E-02	0E+00	0E+00 - 7E-03	2-00056	Kitchen adj. carpet	0E+00	0E+00 - 2E-02	0E+00	0E+00 - 7E-03

(a) Full period indoor air samples, collected during scenario activities (excludes decon samples).
(b) TEM air concentrations based on PCMEla

3A: Sweeping or moving debris/insulation in attic
3B: Cutting holes into ceilings or walls
3C: Replacing or removing carpeting
3D: Removing vermiculite via hand-bagging
3E: Removing vermiculite via vacuum truck

Table 7-1
Summary of Air Samples Utilized in the Personal vs. Stationary Evaluation
Scenario 4: Rototilling

Property ID	Personal Air Monitor Samples (a)						Stationary Air Monitor Samples (a)					
	Index ID	Monitor Type	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI	Index ID	Monitor Location	TEM Air Conc (b) (s/cc)	90% Poisson CI	PCM Air Conc (s/cc)	90% Poisson CI
Z	2-01187	Rototiller	7E-02	6E-02 - 2E-01	2E-01	2E-01 - 3E-01	2-01195	Northeast	0E+00	0E+00 - 2E-02	0E+00	0E+00 - 4E-03
	2-01191	Rototiller asst.	0E+00	0E+00 - 6E-02	2E-02	6E-03 - 4E-02	2-01196	Northwest	3E-03	2E-03 - 1E-02	7E-03	3E-03 - 2E-02
							2-01197	Southwest	0E+00	0E+00 - 2E-02	9E-03	4E-03 - 2E-02
							2-01198	Southeast	5E-03	4E-03 - 1E-02	3E-02	2E-02 - 5E-02

(a) Full period outdoor air samples, collected during scenario activities.
(b) TEM air concentrations based on PCMEla

Table 7-2
Comparison of Personal and Stationary Air Concentrations During Scenario Activities

Analysis Method	Air Conc. Metric	Phase 2 Scenario	Personal						Stationary						Method 1[c]		Method 2[d]
			N Samples	N Properties	Mean[a]	StDev[b]	Min	Max	N Samples	N Properties	Mean[a]	StDev[b]	Min	Max	N Detect Pairs[e]	Mean	Mean
PCM	PCM	Sc1	11	11	0.0067	0.0063	0	0.0163	23	14	0.0048	0.0034	0	0.0121	9	1.4	1.4
		Sc2	39	21	0.1241	0.1616	0	0.5452	23	15	0.0965	0.2869	0.0068	1.1292	15	5.6	1.3
		Sc3	10	6	0.2796	0.5006	0	1.2874	9	5	0.0902	0.0961	0.00	0.2302	4	3.4	3.1
		Sc4	2	1	0.1227	--	0.1227	0.1227	4	1	0.0118	--	0.0118	0.0118	1	10.4	10.4
TEM	PCMEasb	Sc1	16	16	0.0002	0.0006	0	0.0020	26	16	0.0002	0.0003	0	0.0008	3	3.7	1.2
		Sc2	43	23	0.0016	0.0034	0	0.0103	34	23	0.0009	0.0023	0	0.0094	2	2.2	1.7
		Sc3	11	7	0.2704	0.3317	0	0.7752	12	7	0.1033	0.1603	0	0.3941	3	2.5	2.6
		Sc4	2	1	0.0332	--	0.0332	0.0332	4	1	0.0020	--	0.0020	0.0020	1	16.6	16.6
	PCME$_{LA}$	Sc1	16	16	0.0002	0.0006	0	0.0020	26	16	0.0002	0.0003	0	0.0008	3	3.7	1.4
		Sc2	43	23	0.0011	0.0029	0	0.0103	34	23	0.0008	0.0018	0	0.0063	2	2.4	1.5
		Sc3	11	7	0.2599	0.3304	0	0.7507	12	7	0.1033	0.1603	0	0.3941	3	2.5	2.5
		Sc4	2	1	0.0332	--	0.0332	0.0332	4	1	0.0020	--	0.0020	0.0020	1	16.6	16.6
	Total LA	Sc1	16	16	0.0003	0.0006	0	0.0020	26	16	0.0003	0.0005	0	0.0016	4	1.4	1.0
		Sc2	43	23	0.0046	0.0115	0	0.0534	34	23	0.0012	0.0030	0	0.0102	2	2.2	3.7
		Sc3	11	7	0.3973	0.4757	0	1.1642	12	7	0.3593	0.4733	0	1.2021	4	1.3	1.1
		Sc4	2	1	0.0332	--	0.0332	0.0332	4	1	0.0053	--	0.0053	0.0053	1	6.3	6.3

[a] NDs evaluated at 0; average concentrations were calculated first within a house then across all houses.

[b] Standard devation across houses.

[c] Method 1: Mean of personal/stationary ratios, includes only those personal/stationary pairs that were both detect.

[d] Method 2: Mean personal/mean stationary, includes all samples.

[e] Includes only those personal/stationary pairs that were both detect.

-- = statistic could not be calculated

Table 7-3
Results of Statistical Comparison of Personal and Stationary Air Concentrations

Scenario	Property ID	PCM Personal Air Conc (s/cc) (a)	PCM Stationary Air Conc (s/cc) (a)	PCM Ratio Personal/ Stationary	PCM p value (b)	PCM conclusion	TEM PCMEasb Personal Air Conc (s/cc) (a)	TEM PCMEasb Stationary Air Conc (s/cc) (a)	TEM PCMEasb Ratio Personal/ Stationary	TEM PCMEasb p value (b)	TEM PCMEasb conclusion	TEM Total LA Personal Air Conc (s/cc) (a)	TEM Total LA Stationary Air Conc (s/cc) (a)	TEM Total LA Ratio Personal/ Stationary	TEM Total LA p value (b)	TEM Total LA conclusion	TEM PCME$_{LA}$ Personal Air Conc (s/cc) (a)	TEM PCME$_{LA}$ Stationary Air Conc (s/cc) (a)	TEM PCME$_{LA}$ Ratio Personal/ Stationary	TEM PCME$_{LA}$ p value (b)	TEM PCME$_{LA}$ conclusion
1: Routine Activity	AA		3.2E-03	NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	AB	1.6E-03	1.5E-03	1.03	0.93		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	AC			NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	B		1.5E-03	NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	D	0.0E+00	7.6E-03	NC	<0.0001	Stat > Pers	5.0E-04	2.8E-04	1.76	0.53	not different	7.5E-04	6.6E-04	1.13	0.86	not different	5.0E-04	2.8E-04	1.76	0.53	not different
	G	7.5E-03	5.7E-03	1.31	0.06		2.0E-03	2.6E-04	7.91	0.028	Pers > Stat	2.0E-03	1.3E-03	1.58	0.49	not different	2.0E-03	2.6E-04	7.91	0.028	Pers > Stat
	M	1.6E-02	4.4E-03	3.57	0.02	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	N	1.6E-02	8.8E-03	1.85	0.29		0.0E+00	8.0E-04	NC	0.21	not different	5.2E-04	2.7E-04	1.95	0.63	not different	0.0E+00	2.7E-04	NC	0.47	
	O	1.4E-02	1.2E-02	1.15	0.32		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	Q	0.0E+00	0.0E+00	NC	Both ND		1.0E-03	7.8E-04	1.33	0.71	not different	1.3E-03	1.6E-03	0.83	0.76	not different	1.0E-03	7.8E-04	1.33	0.71	not different
	R		3.6E-03	NC			0.0E+00	2.7E-04	NC	0.30	not different	0.0E+00	2.7E-04	NC	0.30	not different	0.0E+00	2.7E-04	NC	0.30	not different
	S	1.2E-03	1.5E-03	0.78	0.52		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	T			NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	U	3.5E-03	4.6E-03	0.77	0.19		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	X	1.0E-02	8.0E-03	1.29	0.08		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	Y	4.1E-03	5.1E-03	0.80	0.23		0.0E+00	7.0E-04	NC	0.32	not different	0.0E+00	7.0E-04	NC	0.32	not different	0.0E+00	7.0E-04	NC	0.32	not different
2: Active Cleaning	AA	3.5E-02		NC			1.9E-03	0.0E+00	NC	0.63	not different	5.6E-03	0.0E+00	NC	0.40	not different	1.9E-03	0.0E+00	NC	0.63	not different
	AC	7.9E-02	1.6E-02	5.08	<0.0001	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		1.7E-02	0.0E+00	NC	0.12	not different	0.0E+00	0.0E+00	NC	Both ND	
	B	3.7E-02	1.1E-02	3.45	<0.0001	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	C	0.0E+00		NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	D (barn)	8.3E-02		NC			0.0E+00	4.7E-03	NC	0.63	not different	0.0E+00	1.2E-02	NC	0.44	not different	0.0E+00	4.7E-03	NC	0.63	
	D (indoor)	2.5E-02	1.4E-02	1.83	0.01	Pers > Stat	0.0E+00	5.2E-03	NC	0.45	not different	0.0E+00	6.5E-03	NC	0.40	not different	0.0E+00	5.2E-03	NC	0.45	
	E (barn)			NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	E (indoor)	7.1E-02	1.1E+00	0.06	<0.0001	Stat > Pers	0.0E+00	0.0E+00	NC	Both ND		7.8E-03	0.0E+00	NC	0.90		0.0E+00	0.0E+00	NC	Both ND	
	F	1.1E-01	4.2E-02	2.51	<0.0001	Stat > Pers	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	G	1.7E-02	1.8E-02	0.93	0.78		8.2E-03	0.0E+00	NC	0.31	not different	1.1E-02	0.0E+00	NC	0.23	not different	8.2E-03	0.0E+00	NC	0.31	not different
	I	9.1E-02		NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	J	2.9E-02	1.0E-02	2.82	0.0006	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	M	2.5E-02	2.0E-02	1.27	0.44		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	O	3.3E-02	6.9E-03	4.86	<0.0001	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		1.2E-03	0.0E+00	NC	0.70	not different	0.0E+00	0.0E+00	NC	Both ND	
	P	2.6E-02	6.9E-03	3.73	0.002	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	Q	5.7E-02	1.8E-02	3.21	<0.0001	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	T	5.1E-02	6.8E-03	7.55	<0.0001	Pers > Stat	9.6E-03	0.0E+00	NC	0.25		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	U	2.4E-02	1.1E-02	2.14	0.008	Pers > Stat	1.0E-02	3.0E-03	3.39	0.36	not different	1.0E-02	3.0E-03	3.39	0.36	not different	1.0E-02	3.0E-03	3.39	0.36	not different
	V	1.7E-01		NC			1.1E-02	9.4E-03	1.12	0.90	not different	1.1E-02	9.4E-03	1.12	0.90	not different	1.1E-02	6.3E-03	1.69	0.60	not different
	X (garage)	5.0E-01	1.1E-01	4.58	0.004	Pers > Stat	0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	X (indoor)	4.2E-02	2.7E-02	1.56	0.11		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
	Y	4.0E-01		NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
3: Active Disturbance of Vermiculite	A			NC			6.8E-03	0.0E+00	NC	0.16	not different	1.4E-02	0.0E+00	NC	0.04	Pers > Stat	6.8E-03	0.0E+00	NC	0.16	not different
	B	1.2E+00	3.3E-02	35.63	<0.0001	Pers > Stat	8.1E-01	1.4E-02	59.64	<0.0001	Pers > Stat	1.3E+00	4.2E-02	30.78	<0.0001	Pers > Stat	7.7E-01	1.4E-02	56.66	<0.0001	Pers > Stat
	E			NC			9.3E-02	0.0E+00	NC	0.48	not different	6.2E-02	3.8E-01	0.16	0.039	Stat > Pers	6.2E-02	0.0E+00	NC	0.57	not different
	K	1.7E-01	5.2E-02	3.33	<0.0001	Pers > Stat	2.4E-01	6.9E-02	3.45	0.0005	Pers > Stat	4.8E-01	1.4E-01	3.45	<0.0001	Pers > Stat	2.4E-01	6.9E-02	3.45	0.0005	Pers > Stat
	L	1.9E-01	2.3E-01	0.80	0.32		1.2E-01	0.0E+00	NC	0.19	not different	2.4E-01	0.0E+00	NC	0.06	not different	1.2E-01	0.0E+00	NC	0.19	
	N			NC			0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND		0.0E+00	0.0E+00	NC	Both ND	
4: Rototilling	Z	1.2E-01	1.2E-02	9.99	<0.0001	Pers > Stat	1.5E-02	2.7E-03	5.36	0.10	not different	1.5E-02	7.3E-03	2.01	0.50	not different	1.5E-02	2.7E-03	5.36	0.10	not different

(a) Mean personal and mean stationary air concentration for each property.

(b) Nelson (1982)

NC = Not Calculated, personal and/or stationary air concentration was non-detect

▮ Statistically significant p <0.05

Table 7-3 Stat Sig Summ.xls, 3/29/2006

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI		PCM Air Conc (s/cc)	PCM 90% Poisson CI	
1	AA	Stationary	TWA	2-00072	0E+00	0E+00 -	8E-04	4E-03	1E-03 -	1E-03
1	AA	Stationary	TWA	2-00073	0E+00	0E+00 -	8E-04	2E-03	7E-04 -	1E-03
1	AB	Personal	TWA	2-00076	0E+00	0E+00 -	8E-04	2E-03	6E-04 -	8E-04
1	AB	Stationary	TWA	2-00077	0E+00	0E+00 -	8E-04	2E-03	5E-04 -	9E-04
1	B	Stationary	TWA	2-00081	0E+00	0E+00 -	8E-04	2E-03	7E-04 -	1E-03
1	B	Stationary	TWA	2-00082	0E+00	0E+00 -	2E-03	6E-04	3E-04 -	6E-04
1	D	Personal	TWA	2-00018	5E-04	4E-04 -	1E-03	0E+00	0E+00 -	3E-04
1	D	Stationary	TWA	2-00019	0E+00	0E+00 -	8E-04	9E-03	2E-03 -	2E-03
1	D	Stationary	TWA	2-00020	3E-04	3E-04 -	1E-03	5E-03	1E-03 -	1E-03
1	D	Stationary	TWA	2-00021	5E-04	4E-04 -	1E-03	8E-03	1E-03 -	2E-03
1	G	Personal	TWA	2-00247	2E-03	1E-03 -	3E-03	8E-03	1E-03 -	2E-03
1	G	Stationary	TWA	2-00248	5E-04	5E-04 -	2E-03	6E-03	1E-03 -	1E-03
1	G	Stationary	TWA	2-00249	0E+00	0E+00 -	2E-03	5E-03	1E-03 -	1E-03
1	M	Personal	TWA	2-00165	0E+00	0E+00 -	6E-04	2E-02	1E-02 -	2E-02
1	M	Stationary	TWA	2-00166	0E+00	0E+00 -	1E-03	4E-03	1E-03 -	1E-03
1	N	Personal	TWA	2-00155	0E+00	0E+00 -	2E-03	2E-02	1E-02 -	3E-02
1	N	Stationary	TWA	2-00156	5E-04	5E-04 -	2E-03	1E-02	2E-03 -	2E-03
1	N	Stationary	TWA	2-00157	0E+00	0E+00 -	2E-03	6E-03	1E-03 -	1E-03
1	O	Personal	TWA	2-00026	0E+00	0E+00 -	4E-03	1E-02	2E-03 -	2E-03
1	O	Stationary	TWA	2-00027	0E+00	0E+00 -	4E-03	1E-02	2E-03 -	2E-03
1	Q	Personal	TWA	2-00022	1E-03	7E-04 -	1E-03	0E+00	0E+00 -	3E-04
1	Q	Stationary	TWA	2-00023	8E-04	6E-04 -	1E-03	0E+00	0E+00 -	3E-04
1	R	Stationary	TWA	2-00036	3E-04	2E-04 -	1E-03	4E-03	1E-03 -	1E-03
1	R	Stationary	TWA	2-00037	3E-04	3E-04 -	1E-03	3E-03	9E-04 -	1E-03
1	S	Personal	TWA	2-01041	0E+00	0E+00 -	4E-03	1E-03	5E-04 -	7E-04
1	S	Stationary	TWA	2-01042	0E+00	0E+00 -	4E-03	1E-03	5E-04 -	8E-04
1	U	Personal	TWA	2-00044	0E+00	0E+00 -	9E-04	4E-03	9E-04 -	1E-03
1	U	Stationary	TWA	2-00045	0E+00	0E+00 -	9E-04	4E-03	1E-03 -	1E-03
1	U	Stationary	TWA	2-00046	0E+00	0E+00 -	9E-04	5E-03	1E-03 -	1E-03
1	X	Personal	TWA	2-00040	0E+00	0E+00 -	7E-04	1E-02	2E-03 -	2E-03
1	X	Stationary	TWA	2-00041	0E+00	0E+00 -	7E-04	8E-03	1E-03 -	2E-03
1	Y	Personal	TWA	2-00030	0E+00	0E+00 -	2E-03	4E-03	1E-03 -	1E-03
1	Y	Stationary	TWA	2-00031	0E+00	0E+00 -	2E-03	5E-03	1E-03 -	1E-03
1	Y	Stationary	TWA	2-00032	1E-03	1E-03 -	3E-03	5E-03	1E-03 -	1E-03
2A	A	Personal	EXC	2-00066	0E+00	0E+00 -	4E-02	2E-02	1E-02 -	3E-02
2A	A	Personal	TWA	2-00067	0E+00	0E+00 -	2E-02	0E+00	0E+00 -	7E-03
2A	AA	Personal	EXC	2-00538	0E+00	0E+00 -	4E-02	1E-01	4E-02 -	5E-02
2A	AA	Personal	EXC	2-00541	0E+00	0E+00 -	2E-01	4E-02	2E-02 -	3E-02
2A	AA	Personal	EXC	2-00543	0E+00	0E+00 -	4E-02	2E-01	4E-02 -	5E-02
2A	AA	Personal	EXC	2-00545	0E+00	0E+00 -	2E-01	3E-02	2E-02 -	3E-02
2A	AA	Personal	TWA	2-00537	0E+00	0E+00 -	1E-02	3E-02	9E-03 -	1E-02
2A	AA	Personal	TWA	2-00540	0E+00	0E+00 -	3E-03	8E-03	3E-03 -	4E-03
2A	AA	Personal	TWA	2-00542	3E-03	3E-03 -	1E-02	4E-02	1E-02 -	1E-02
2A	AA	Personal	TWA	2-00544	1E-03	1E-03 -	4E-03	9E-03	3E-03 -	4E-03
2A	AC	Personal	EXC	2-00409	0E+00	0E+00 -	2E-01	3E-02	2E-02 -	3E-02
2A	AC	Personal	EXC	2-00412	0E+00	0E+00 -	2E-01	6E-02	2E-02 -	3E-02
2A	AC	Personal	EXC	2-00416	0E+00	0E+00 -	1E-01	6E-02	3E-02 -	4E-02
2A	AC	Personal	EXC	2-00418	0E+00	0E+00 -	1E-01	3E-02	2E-02 -	4E-02
2A	AC	Personal	TWA	2-00408	0E+00	0E+00 -	3E-01	3E-01	9E-02 -	1E-01
2A	AC	Personal	TWA	2-00411	0E+00	0E+00 -	6E-02	4E-02	1E-02 -	2E-02
2A	AC	Personal	TWA	2-00415	9E-03	9E-03 -	4E-02	2E-02	5E-03 -	7E-03
2A	AC	Personal	TWA	2-00417	0E+00	0E+00 -	3E-02	1E-02	4E-03 -	6E-03
2A	AC	Stationary	TWA	2-00398	0E+00	0E+00 -	2E-02	2E-02	7E-03 -	1E-02
2A	B	Personal	EXC	2-00342	0E+00	0E+00 -	2E-01	4E-02	2E-02 -	3E-02
2A	B	Personal	EXC	2-00345	0E+00	0E+00 -	2E-01	3E-02	2E-02 -	3E-02
2A	B	Personal	EXC	2-00352	0E+00	0E+00 -	3E-01	4E-02	2E-02 -	4E-02
2A	B	Personal	EXC	2-00354	0E+00	0E+00 -	3E-01	3E-02	2E-02 -	4E-02
2A	B	Personal	TWA	2-00341	0E+00	0E+00 -	5E-02	5E-02	1E-02 -	2E-02

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI			PCM Air Conc (s/cc)	PCM 90% Poisson CI		
2A	B	Personal	TWA	2-00344	0E+00	0E+00	-	5E-02	3E-02	9E-03	-	1E-02
2A	B	Personal	TWA	2-00351	0E+00	0E+00	-	1E-01	4E-01	1E-01	-	1E-01
2A	B	Personal	TWA	2-00353	0E+00	0E+00	-	1E-02	1E-02	4E-03	-	5E-03
2A	B	Stationary	TWA	2-00323	0E+00	0E+00	-	4E-02	2E-02	6E-03	-	1E-02
2A	B	Stationary	TWA	2-00324	0E+00	0E+00	-	5E-02	4E-03	3E-03	-	6E-03
2A	C	Personal	EXC	2-00150	0E+00	0E+00	-	4E-02	0E+00	0E+00	-	1E-02
2A	C	Personal	EXC	2-00153	0E+00	0E+00	-	2E-02	8E-02	2E-02	-	3E-02
2A	C	Personal	EXC	2-00154	0E+00	0E+00	-	5E-02	2E-01	5E-02	-	7E-02
2A	C	Personal	TWA	2-00149	0E+00	0E+00	-	1E-02	0E+00	0E+00	-	5E-03
2A	C	Personal	TWA	2-00152	0E+00	0E+00	-	1E-02	0E+00	0E+00	-	5E-03
2A	D	Personal	EXC	2-00187	0E+00	0E+00	-	2E-01	2E-01	5E-02	-	6E-02
2A	D	Personal	EXC	2-00189	0E+00	0E+00	-	2E-01	6E-02	3E-02	-	4E-02
2A	D	Personal	EXC	2-00190	0E+00	0E+00	-	2E-01	4E-02	2E-02	-	3E-02
2A	D	Personal	EXC	2-00191	0E+00	0E+00	-	4E-01	2E-01	6E-02	-	9E-02
2A	D	Personal	EXC	2-00241	0E+00	0E+00	-	2E-01	2E-02	1E-02	-	2E-02
2A	D	Personal	EXC	2-00244	0E+00	0E+00	-	2E-01	2E-02	1E-02	-	3E-02
2A	D	Personal	TWA	2-00188	0E+00	0E+00	-	7E-02	8E-02	2E-02	-	2E-02
2A	D	Personal	TWA	2-00240	0E+00	0E+00	-	5E-02	3E-02	1E-02	-	1E-02
2A	D	Personal	TWA	2-00243	0E+00	0E+00	-	5E-02	2E-02	8E-03	-	1E-02
2A	D	Stationary	TWA	2-00220	3E-03	3E-03	-	1E-02	1E-02	6E-03	-	9E-03
2A	D	Stationary	TWA	2-00222	3E-03	3E-03	-	1E-02	2E-02	6E-03	-	9E-03
2A	D	Stationary	TWA	2-00224	7E-03	5E-03	-	1E-02	1E-02	6E-03	-	9E-03
2A	E	Personal	EXC	2-00092	0E+00	0E+00	-	4E-02	8E-02	3E-02	-	4E-02
2A	E	Personal	EXC	2-00093	0E+00	0E+00	-	4E-02	0E+00	0E+00	-	6E-03
2A	E	Personal	EXC	2-00976	1E-02	1E-02	-	4E-02	1E-01	3E-02	-	3E-02
2A	E	Personal	EXC	2-00977	0E+00	0E+00	-	8E-02	3E-01	7E-02	-	8E-02
2A	E	Personal	EXC	2-00978	0E+00	0E+00	-	1E-01	1E-01	4E-02	-	6E-02
2A	E	Personal	EXC	2-00980	0E+00	0E+00	-	3E-02	1E-01	2E-02	-	3E-02
2A	E	Personal	EXC	2-00981	0E+00	0E+00	-	8E-02	2E-01	5E-02	-	6E-02
2A	E	Personal	EXC	2-00982	0E+00	0E+00	-	1E-01	2E-01	5E-02	-	7E-02
2A	E	Personal	EXC	2-00987	0E+00	0E+00	-	7E-02	4E-02	2E-02	-	3E-02
2A	E	Personal	EXC	2-00989	0E+00	0E+00	-	7E-02	4E-02	2E-02	-	3E-02
2A	E	Personal	EXC	2-00999	0E+00	0E+00	-	2E-01	4E-02	2E-02	-	3E-02
2A	E	Personal	EXC	2-01001	0E+00	0E+00	-	2E-01	4E-02	2E-02	-	3E-02
2A	E	Personal	TWA	2-00975	0E+00	0E+00	-	2E-02	4E-02	1E-02	-	1E-02
2A	E	Personal	TWA	2-00979	0E+00	0E+00	-	1E+00	1E-01	2E-02	-	2E-02
2A	E	Personal	TWA	2-00986	0E+00	0E+00	-	4E-03	8E-03	2E-03	-	3E-03
2A	E	Personal	TWA	2-00988	0E+00	0E+00	-	4E-03	1E-02	3E-03	-	3E-03
2A	E	Personal	TWA	2-00998	0E+00	0E+00	-	3E-02	6E-03	3E-03	-	4E-03
2A	E	Personal	TWA	2-01000	0E+00	0E+00	-	3E-02	1E-02	4E-03	-	6E-03
2A	E	Stationary	TWA	2-00968	0E+00	0E+00	-	1E+00	1E+00	3E-01	-	4E-01
2A	F	Personal	EXC	2-00380	0E+00	0E+00	-	2E-01	6E-02	2E-02	-	4E-02
2A	F	Personal	EXC	2-00383	0E+00	0E+00	-	2E-01	2E-01	5E-02	-	6E-02
2A	F	Personal	EXC	2-00391	0E+00	0E+00	-	3E-01	4E-02	2E-02	-	4E-02
2A	F	Personal	EXC	2-00393	0E+00	0E+00	-	3E-01	4E-02	2E-02	-	4E-02
2A	F	Personal	TWA	2-00379	0E+00	0E+00	-	3E-01	1E+00	3E-01	-	4E-01
2A	F	Personal	TWA	2-00382	0E+00	0E+00	-	5E-02	7E-02	1E-02	-	2E-02
2A	F	Personal	TWA	2-00390	8E-03	7E-03	-	3E-02	2E-02	5E-03	-	7E-03
2A	F	Personal	TWA	2-00392	0E+00	0E+00	-	2E-02	2E-02	5E-03	-	6E-03
2A	F	Stationary	TWA	2-00361	0E+00	0E+00	-	5E-02	7E-02	1E-02	-	2E-02
2A	F	Stationary	TWA	2-00362	0E+00	0E+00	-	5E-02	2E-02	6E-03	-	1E-02
2A	G	Personal	EXC	2-00643	0E+00	0E+00	-	2E-02	3E-02	1E-02	-	2E-02
2A	G	Personal	EXC	2-00644	8E-03	8E-03	-	3E-02	4E-02	2E-02	-	3E-02
2A	G	Personal	EXC	2-00645	0E+00	0E+00	-	2E-02	4E-02	2E-02	-	3E-02
2A	G	Personal	EXC	2-00647	0E+00	0E+00	-	2E-02	2E-02	1E-02	-	2E-02
2A	G	Personal	EXC	2-00648	8E-03	8E-03	-	3E-02	4E-02	2E-02	-	3E-02
2A	G	Personal	EXC	2-00649	2E-02	2E-02	-	4E-02	5E-02	2E-02	-	3E-02
2A	G	Personal	EXC	2-00653	0E+00	0E+00	-	4E-02	1E-02	8E-03	-	2E-02

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI			PCM Air Conc (s/cc)	PCM 90% Poisson CI		
2A	G	Personal	EXC	2-00655	0E+00	0E+00	-	4E-02	3E-02	2E-02	-	3E-02
2A	G	Personal	TWA	2-00642	5E-03	4E-03	-	1E-02	2E-02	8E-03	-	1E-02
2A	G	Personal	TWA	2-00646	7E-03	5E-03	-	1E-02	1E-02	6E-03	-	9E-03
2A	G	Personal	TWA	2-00652	0E+00	0E+00	-	4E-03	3E-03	1E-03	-	2E-03
2A	G	Personal	TWA	2-00654	0E+00	0E+00	-	4E-03	6E-03	2E-03	-	3E-03
2A	G	Stationary	TWA	2-00632	0E+00	0E+00	-	5E-02	2E-02	7E-03	-	1E-02
2A	G	Stationary	TWA	2-00633	0E+00	0E+00	-	5E-02	2E-02	7E-03	-	1E-02
2A	I	Personal	EXC	2-01232	0E+00	0E+00	-	5E-02	2E-01	4E-02	-	5E-02
2A	I	Personal	EXC	2-01237	0E+00	0E+00	-	5E-02	9E-02	3E-02	-	4E-02
2A	I	Personal	EXC	2-01242	0E+00	0E+00	-	9E-02	3E-02	2E-02	-	4E-02
2A	I	Personal	EXC	2-01245	0E+00	0E+00	-	8E-02	2E-02	1E-02	-	4E-02
2A	I	Personal	TWA	2-01231	0E+00	0E+00	-	7E-03	9E-02	2E-02	-	2E-02
2A	I	Personal	TWA	2-01236	0E+00	0E+00	-	2E-02	9E-02	2E-02	-	2E-02
2A	I	Personal	TWA	2-01241	0E+00	0E+00	-	8E-03	2E-02	4E-03	-	6E-03
2A	I	Personal	TWA	2-01244	0E+00	0E+00	-	8E-03	1E-02	4E-03	-	5E-03
2A	J	Personal	EXC	2-00922	0E+00	0E+00	-	5E-02	7E-02	2E-02	-	3E-02
2A	J	Personal	EXC	2-00923	2E-02	1E-02	-	6E-02	4E-02	2E-02	-	3E-02
2A	J	Personal	EXC	2-00924	0E+00	0E+00	-	5E-02	3E-02	2E-02	-	3E-02
2A	J	Personal	EXC	2-00932	0E+00	0E+00	-	2E-01	2E-02	1E-02	-	3E-02
2A	J	Personal	EXC	2-00934	0E+00	0E+00	-	2E-01	3E-02	2E-02	-	3E-02
2A	J	Personal	EXC	2-00953	0E+00	0E+00	-	2E-01	2E-02	1E-02	-	3E-02
2A	J	Personal	EXC	2-00955	0E+00	0E+00	-	2E-01	3E-02	2E-02	-	3E-02
2A	J	Personal	TWA	2-00921	0E+00	0E+00	-	2E-02	3E-02	9E-03	-	1E-02
2A	J	Personal	TWA	2-00931	0E+00	0E+00	-	1E-02	5E-03	2E-03	-	3E-03
2A	J	Personal	TWA	2-00933	0E+00	0E+00	-	1E-02	7E-03	2E-03	-	3E-03
2A	J	Personal	TWA	2-00952	0E+00	0E+00	-	3E-02	5E-03	3E-03	-	5E-03
2A	J	Personal	TWA	2-00954	0E+00	0E+00	-	3E-02	1E-02	5E-03	-	7E-03
2A	J	Stationary	TWA	2-00911	0E+00	0E+00	-	5E-02	5E-03	3E-03	-	6E-03
2A	J	Stationary	TWA	2-00912	0E+00	0E+00	-	5E-02	2E-02	6E-03	-	9E-03
2A	M	Personal	EXC	2-00875	0E+00	0E+00	-	5E-02	7E-02	2E-02	-	3E-02
2A	M	Personal	EXC	2-00876	0E+00	0E+00	-	5E-02	4E-02	2E-02	-	3E-02
2A	M	Personal	EXC	2-00877	0E+00	0E+00	-	6E-02	7E-02	3E-02	-	4E-02
2A	M	Personal	EXC	2-00879	0E+00	0E+00	-	5E-02	8E-02	3E-02	-	4E-02
2A	M	Personal	EXC	2-00880	0E+00	0E+00	-	5E-02	8E-02	3E-02	-	4E-02
2A	M	Personal	EXC	2-00881	2E-02	2E-02	-	8E-02	1E-01	3E-02	-	4E-02
2A	M	Personal	EXC	2-00885	0E+00	0E+00	-	2E-01	4E-02	2E-02	-	3E-02
2A	M	Personal	EXC	2-00887	0E+00	0E+00	-	2E-01	4E-02	2E-02	-	3E-02
2A	M	Personal	TWA	2-00874	0E+00	0E+00	-	2E-02	2E-02	7E-03	-	1E-02
2A	M	Personal	TWA	2-00878	0E+00	0E+00	-	2E-02	3E-02	1E-02	-	1E-02
2A	M	Personal	TWA	2-00884	0E+00	0E+00	-	1E-02	5E-03	2E-03	-	3E-03
2A	M	Stationary	TWA	2-00867	0E+00	0E+00	-	5E-02	2E-02	8E-03	-	1E-02
2A	O	Personal	EXC	2-01063	7E-03	6E-03	-	3E-02	2E-02	1E-02	-	2E-02
2A	O	Personal	EXC	2-01064	0E+00	0E+00	-	3E-02	2E-02	1E-02	-	3E-02
2A	O	Personal	EXC	2-01065	0E+00	0E+00	-	4E-02	5E-02	3E-02	-	4E-02
2A	O	Personal	EXC	2-01067	0E+00	0E+00	-	2E-02	3E-02	1E-02	-	2E-02
2A	O	Personal	EXC	2-01073	0E+00	0E+00	-	3E-02	2E-02	1E-02	-	2E-02
2A	O	Personal	EXC	2-01075	0E+00	0E+00	-	3E-02	3E-02	2E-02	-	3E-02
2A	O	Personal	TWA	2-01062	0E+00	0E+00	-	7E-03	3E-02	1E-02	-	1E-02
2A	O	Personal	TWA	2-01066	0E+00	0E+00	-	7E-03	3E-02	9E-03	-	1E-02
2A	O	Personal	TWA	2-01072	0E+00	0E+00	-	2E-03	7E-03	2E-03	-	3E-03
2A	O	Personal	TWA	2-01074	0E+00	0E+00	-	2E-03	3E-03	1E-03	-	2E-03
2A	O	Stationary	TWA	2-01055	0E+00	0E+00	-	2E-02	7E-03	4E-03	-	8E-03
2A	P	Personal	EXC	2-00794	0E+00	0E+00	-	5E-02	5E-02	2E-02	-	3E-02
2A	P	Personal	EXC	2-00795	0E+00	0E+00	-	5E-02	7E-02	2E-02	-	3E-02
2A	P	Personal	EXC	2-00796	0E+00	0E+00	-	5E-02	9E-02	3E-02	-	4E-02
2A	P	Personal	EXC	2-00798	0E+00	0E+00	-	5E-02	6E-02	2E-02	-	3E-02
2A	P	Personal	EXC	2-00799	0E+00	0E+00	-	5E-02	9E-02	3E-02	-	4E-02
2A	P	Personal	EXC	2-00800	0E+00	0E+00	-	5E-02	7E-02	3E-02	-	3E-02

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI		PCM Air Conc (s/cc)	PCM 90% Poisson CI	
2A	P	Personal	EXC	2-00804	0E+00	0E+00 -	2E-01	1E-02	8E-03 -	2E-02
2A	P	Personal	EXC	2-00806	0E+00	0E+00 -	2E-01	1E-02	1E-02 -	2E-02
2A	P	Personal	TWA	2-00793	0E+00	0E+00 -	1E+00	3E-01	2E-01 -	2E-01
2A	P	Personal	TWA	2-00797	0E+00	0E+00 -	2E-02	1E-02	6E-03 -	9E-03
2A	P	Personal	TWA	2-00803	0E+00	0E+00 -	1E-02	4E-03	2E-03 -	3E-03
2A	P	Personal	TWA	2-00805	0E+00	0E+00 -	1E-02	7E-03	2E-03 -	3E-03
2A	P	Stationary	TWA	2-00478	0E+00	0E+00 -	4E-02	7E-03	4E-03 -	7E-03
2A	Q	Personal	EXC	2-00210	0E+00	0E+00 -	2E-01	1E-02	7E-03 -	1E-02
2A	Q	Personal	EXC	2-00212	0E+00	0E+00 -	2E-01	2E-02	7E-03 -	1E-02
2A	Q	Personal	TWA	2-00209	0E+00	0E+00 -	8E-02	7E-02	2E-02 -	2E-02
2A	Q	Personal	TWA	2-00211	0E+00	0E+00 -	8E-02	4E-02	1E-02 -	2E-02
2A	Q	Stationary	TWA	2-00194	0E+00	0E+00 -	7E-03	2E-02	6E-03 -	8E-03
2A	T	Personal	EXC	2-00444	0E+00	0E+00 -	2E-01	6E-02	3E-02 -	4E-02
2A	T	Personal	EXC	2-00447	0E+00	0E+00 -	2E-01	7E-02	3E-02 -	4E-02
2A	T	Personal	EXC	2-00451	0E+00	0E+00 -	3E-01	4E-02	2E-02 -	4E-02
2A	T	Personal	EXC	2-00453	0E+00	0E+00 -	3E-01	6E-02	3E-02 -	5E-02
2A	T	Personal	EXC	2-00461	0E+00	0E+00 -	3E-01	8E-02	4E-02 -	5E-02
2A	T	Personal	EXC	2-00463	0E+00	0E+00 -	3E-01	5E-02	3E-02 -	5E-02
2A	T	Personal	TWA	2-00443	0E+00	0E+00 -	6E-02	4E-02	1E-02 -	2E-02
2A	T	Personal	TWA	2-00446	0E+00	0E+00 -	6E-02	6E-02	1E-02 -	2E-02
2A	T	Personal	TWA	2-00450	0E+00	0E+00 -	2E-02	1E+00	2E-01 -	2E-01
2A	T	Personal	TWA	2-00452	0E+00	0E+00 -	2E-02	5E-02	9E-03 -	1E-02
2A	T	Personal	TWA	2-00460	0E+00	0E+00 -	4E-02	3E-02	9E-03 -	1E-02
2A	T	Personal	TWA	2-00462	0E+00	0E+00 -	4E-02	2E-02	8E-03 -	1E-02
2A	T	Stationary	TWA	2-00429	0E+00	0E+00 -	4E-02	6E-03	3E-03 -	6E-03
2A	T	Stationary	TWA	2-00430	0E+00	0E+00 -	4E-02	8E-03	4E-03 -	7E-03
2A	U	Personal	EXC	2-00301	0E+00	0E+00 -	2E-01	4E-02	2E-02 -	3E-02
2A	U	Personal	EXC	2-00303	0E+00	0E+00 -	1E-01	5E-02	2E-02 -	3E-02
2A	U	Personal	EXC	2-00315	0E+00	0E+00 -	3E-01	4E-02	2E-02 -	4E-02
2A	U	Personal	EXC	2-00316	0E+00	0E+00 -	3E-01	5E-02	3E-02 -	5E-02
2A	U	Personal	TWA	2-00300	2E-02	2E-02 -	8E-02	3E-02	1E-02 -	1E-02
2A	U	Personal	TWA	2-00302	0E+00	0E+00 -	6E-02	2E-02	9E-03 -	1E-02
2A	U	Personal	TWA	2-00313	7E-03	6E-03 -	3E-02	6E-03	3E-03 -	4E-03
2A	U	Personal	TWA	2-00314	7E-03	6E-03 -	3E-02	9E-03	3E-03 -	4E-03
2A	U	Stationary	TWA	2-00282	6E-03	6E-03 -	2E-02	1E-02	5E-03 -	8E-03
2A	U	Stationary	TWA	2-00283	0E+00	0E+00 -	2E-02	1E-02	6E-03 -	8E-03
2A	V	Personal	EXC	2-00115	0E+00	0E+00 -	4E-02	3E-02	2E-02 -	3E-02
2A	V	Personal	EXC	2-00118	0E+00	0E+00 -	4E-02	4E-02	2E-02 -	3E-02
2A	V	Personal	EXC	2-00127	0E+00	0E+00 -	3E-02	3E-02	1E-02 -	3E-02
2A	V	Personal	EXC	2-00128	0E+00	0E+00 -	4E-02	1E-01	4E-02 -	5E-02
2A	V	Personal	TWA	2-00114	8E-03	7E-03 -	2E-02	2E-01	4E-02 -	5E-02
2A	X	Personal	EXC	2-00274	0E+00	0E+00 -	2E-01	6E-02	3E-02 -	4E-02
2A	X	Personal	EXC	2-00276	0E+00	0E+00 -	2E-01	4E-02	2E-02 -	3E-02
2A	X	Personal	EXC	2-00835	2E-02	2E-02 -	4E-02	1E-01	3E-02 -	5E-02
2A	X	Personal	EXC	2-00837	0E+00	0E+00 -	1E+01	2E+00	1E+00 -	2E+00
2A	X	Personal	EXC	2-00840	0E+00	0E+00 -	7E-02	6E-02	3E-02 -	4E-02
2A	X	Personal	EXC	2-00841	0E+00	0E+00 -	1E-01	1E-01	5E-02 -	7E-02
2A	X	Personal	EXC	2-00842	0E+00	0E+00 -	1E+01	2E+00	1E+00 -	2E+00
2A	X	Personal	EXC	2-00846	0E+00	0E+00 -	2E-01	1E-02	9E-03 -	2E-02
2A	X	Personal	EXC	2-00848	0E+00	0E+00 -	2E-01	3E-02	2E-02 -	3E-02
2A	X	Personal	TWA	2-00273	0E+00	0E+00 -	6E-02	3E-02	9E-03 -	1E-02
2A	X	Personal	TWA	2-00275	0E+00	0E+00 -	6E-02	6E-02	2E-02 -	2E-02
2A	X	Personal	TWA	2-00834	0E+00	0E+00 -	2E+00	4E-01	2E-01 -	4E-01
2A	X	Personal	TWA	2-00839	0E+00	0E+00 -	2E+00	6E-01	3E-01 -	4E-01
2A	X	Personal	TWA	2-00845	0E+00	0E+00 -	2E-02	2E-03	1E-03 -	2E-03
2A	X	Personal	TWA	2-00847	0E+00	0E+00 -	2E-02	3E-03	2E-03 -	3E-03
2A	X	Stationary	TWA	2-00258	0E+00	0E+00 -	1E-02	3E-02	1E-02 -	1E-02
2A	X	Stationary	TWA	2-00828	0E+00	0E+00 -	2E-02	1E-01	7E-02 -	2E-01

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI		PCM Air Conc (s/cc)	PCM 90% Poisson CI	
2A	Y	Personal	EXC	2-00500	0E+00	0E+00 -	5E+00	1E+00	6E-01 -	9E-01
2A	Y	Personal	EXC	2-00511	0E+00	0E+00 -	6E-02	2E-01	7E-02 -	8E-02
2A	Y	Personal	EXC	2-00513	0E+00	0E+00 -	6E-02	1E-01	5E-02 -	7E-02
2A	Y	Personal	TWA	2-00499	0E+00	0E+00 -	3E+00	6E-01	3E-01 -	5E-01
2A	Y	Personal	TWA	2-00502	0E+00	0E+00 -	2E+00	2E-01	1E-01 -	3E-01
2A	Y	Personal	TWA	2-00510	1E-03	1E-03 -	5E-03	1E-01	6E-02 -	9E-02
2A	Y	Personal	TWA	2-00512	0E+00	0E+00 -	4E-03	3E-01	9E-02 -	1E-01
3A	K	Personal	EXC	2-00571	0E+00	0E+00 -	5E-01	6E-01	3E-01 -	6E-01
3A	K	Personal	EXC	2-00586	1E+00	5E-01 -	6E-01	1E+00	3E-01 -	4E-01
3A	L	Personal	EXC	2-00741	2E-01	2E-01 -	4E-01	1E+00	3E-01 -	4E-01
3A	L	Personal	EXC	2-00742	2E-01	2E-01 -	9E-01	9E-01	3E-01 -	5E-01
3A	L	Personal	EXC	2-00746	0E+00	0E+00 -	4E-01	5E-01	2E-01 -	3E-01
3A	L	Personal	EXC	2-00747	0E+00	0E+00 -	9E-01	6E-01	3E-01 -	5E-01
3A/B	B	Stationary	TWA	2-01004	8E-01	3E-01 -	4E-01	3E-01	4E-02 -	5E-02
3A/B	K	Personal	TWA	2-00572	3E-01	1E-01 -	2E-01	3E-01	8E-02 -	1E-01
3A/B	K	Personal	TWA	2-00588	2E-02	2E-02 -	9E-02	6E-02	4E-02 -	7E-02
3A/B	K	Stationary	TWA	2-00566	1E-01	5E-02 -	8E-02	7E-02	3E-02 -	4E-02
3A/B	K	Stationary	TWA	2-00567	2E-02	2E-02 -	4E-02	4E-02	2E-02 -	2E-02
3A/B	K	Stationary	TWA	2-00590	0E+00	0E+00 -	3E-02	2E-03	1E-03 -	4E-03
3A/B	K	Stationary	TWA	2-00591	0E+00	0E+00 -	3E-02	0E+00	0E+00 -	3E-03
3A/B	K	Stationary	TWA	2-00592	0E+00	0E+00 -	3E-02	0E+00	0E+00 -	3E-03
3A/B	K	Stationary	TWA	2-00593	0E+00	0E+00 -	3E-02	0E+00	0E+00 -	3E-03
3A/B	L	Personal	TWA	2-00739	2E-01	1E-01 -	2E-01	3E-01	8E-02 -	1E-01
3A/B	L	Personal	TWA	2-00744	8E-02	6E-02 -	2E-01	1E-01	5E-02 -	7E-02
3A/B	L	Stationary	TWA	2-00726	0E+00	0E+00 -	4E-02	2E-03	2E-03 -	4E-03
3A/B	L	Stationary	TWA	2-00727	0E+00	0E+00 -	4E-02	2E-03	2E-03 -	4E-03
3A/B	L	Stationary	TWA	2-00728	0E+00	0E+00 -	4E-02	0E+00	0E+00 -	3E-03
3A/B	L	Stationary	TWA	2-00729	0E+00	0E+00 -	4E-02	0E+00	0E+00 -	3E-03
3A/B	L	Stationary	TWA	2-00732	0E+00	0E+00 -	4E-01	3E-01	9E-02 -	1E-01
3A/B	L	Stationary	TWA	2-00733	0E+00	0E+00 -	4E-01	1E-01	6E-02 -	8E-02
3A/B/D	K	Personal	EXC	2-00609	0E+00	0E+00 -	4E-02	4E-02	2E-02 -	3E-02
3A/B/D	K	Personal	EXC	2-00610	0E+00	0E+00 -	4E-02	2E-02	1E-02 -	3E-02
3A/B/D	K	Personal	EXC	2-00757	0E+00	0E+00 -	3E-01	3E-02	2E-02 -	4E-02
3A/B/D	K	Personal	EXC	2-00759	0E+00	0E+00 -	3E-01	7E-02	3E-02 -	5E-02
3A/B/D	K	Personal	TWA	2-00608	0E+00	0E+00 -	4E-03	6E-03	2E-03 -	3E-03
3A/B/D	K	Personal	TWA	2-00611	0E+00	0E+00 -	3E-03	5E-03	2E-03 -	3E-03
3A/B/D	K	Personal	TWA	2-00756	0E+00	0E+00 -	3E-02	2E-02	5E-03 -	7E-03
3A/B/D	K	Personal	TWA	2-00758	1E-02	1E-02 -	4E-02	2E-02	6E-03 -	7E-03
3A/B/D	L	Personal	EXC	2-00778	0E+00	0E+00 -	3E-01	5E-02	3E-02 -	4E-02
3A/B/D	L	Personal	EXC	2-00780	0E+00	0E+00 -	3E-01	7E-02	3E-02 -	5E-02
3A/B/D	L	Personal	TWA	2-00777	0E+00	0E+00 -	2E+00	0E+00	0E+00 -	1E-01
3A/B/D	L	Personal	TWA	2-00779	0E+00	0E+00 -	2E+00	0E+00	0E+00 -	1E-01
3B	B	Personal	EXC	2-01028	5E+00	2E+00 -	3E+00	4E+00	1E+00 -	1E+00
3B	B	Personal	TWA	2-01027	7E-01	5E-01 -	1E+00	2E+00	5E-01 -	6E-01
3B	B	Stationary	TWA	2-01024	0E+00	0E+00 -	3E-02	2E-02	1E-02 -	4E-02
3B	K	Personal	EXC	2-00570	2E-01	1E-01 -	4E-01	1E-01	1E-01 -	2E-01
3B	K	Personal	EXC	2-00573	0E+00	0E+00 -	4E-01	0E+00	0E+00 -	2E-01
3B	K	Personal	EXC	2-00587	5E-01	2E-01 -	4E-01	3E-01	1E-01 -	2E-01
3B	K	Personal	EXC	2-00589	1E-01	8E-02 -	2E-01	1E-01	8E-02 -	2E-01
3B	L	Personal	EXC	2-00740	0E+00	0E+00 -	2E-01	1E-01	6E-02 -	1E-01
3B	L	Personal	EXC	2-00745	0E+00	0E+00 -	2E-01	8E-02	5E-02 -	1E-01
3C	A	Personal	TWA	2-00058	0E+00	0E+00 -	2E-02	0E+00	0E+00 -	7E-03
3C	A	Stationary	TWA	2-00056	0E+00	0E+00 -	2E-02	0E+00	0E+00 -	7E-03
3C	E	Personal	EXC	2-01279	3E-02	2E-02 -	1E-01	3E-02	1E-02 -	2E-02
3C	E	Personal	EXC	2-01280	0E+00	0E+00 -	8E-02	2E-02	1E-02 -	2E-02
3C	E	Personal	EXC	2-01281	4E-02	3E-02 -	9E-02	5E-02	2E-02 -	4E-02
3C	E	Personal	EXC	2-01283	0E+00	0E+00 -	2E-01	4E-02	2E-02 -	2E-02
3C	E	Personal	EXC	2-01284	0E+00	0E+00 -	2E-01	2E-02	1E-02 -	2E-02

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI		PCM Air Conc (s/cc)	PCM 90% Poisson CI	
3C	E	Personal	EXC	2-01285	0E+00	0E+00 -	1E-01	8E-02	3E-02 -	5E-02
3C	E	Personal	TWA	2-01278	9E-02	8E-02 -	2E-01	1E-02	6E-03 -	9E-03
3C	E	Personal	TWA	2-01282	0E+00	0E+00 -	3E-01	1E-02	5E-03 -	9E-03
3C	N	Personal	EXC	2-00694	0E+00	0E+00 -	2E-02	1E-01	3E-02 -	4E-02
3C	N	Personal	EXC	2-00695	0E+00	0E+00 -	2E-02	1E-01	3E-02 -	4E-02
3C	N	Personal	EXC	2-00696	0E+00	0E+00 -	3E-02	4E-02	1E-02 -	2E-02
3C	N	Personal	EXC	2-00698	3E-02	3E-02 -	7E-02	2E-01	4E-02 -	5E-02
3C	N	Personal	EXC	2-00699	0E+00	0E+00 -	2E-02	1E-01	4E-02 -	4E-02
3C	N	Personal	EXC	2-00700	0E+00	0E+00 -	3E-02	5E-02	2E-02 -	2E-02
3C	N	Personal	EXC	2-00704	0E+00	0E+00 -	2E-01	1E-02	1E-02 -	2E-02
3C	N	Personal	EXC	2-00706	0E+00	0E+00 -	2E-01	4E-02	2E-02 -	3E-02
3C	N	Personal	TWA	2-00693	0E+00	0E+00 -	1E-02	2E-02	7E-03 -	9E-03
3C	N	Personal	TWA	2-00697	4E-03	4E-03 -	2E-02	4E-02	1E-02 -	1E-02
3C	N	Personal	TWA	2-00703	0E+00	0E+00 -	1E-02	7E-03	2E-03 -	3E-03
3C	N	Personal	TWA	2-00705	0E+00	0E+00 -	1E-02	1E-02	3E-03 -	4E-03
3C	N	Stationary	TWA	2-00683	0E+00	0E+00 -	4E-02	1E-02	6E-03 -	8E-03
3C	N	Stationary	TWA	2-00685	0E+00	0E+00 -	4E-02	3E-02	8E-03 -	1E-02
3E	A	Personal	EXC	2-01152	0E+00	0E+00 -	1E-01	2E-01	9E-02 -	1E-01
3E	A	Personal	EXC	2-01154	0E+00	0E+00 -	2E-01	1E-01	7E-02 -	1E-01
3E	A	Personal	TWA	2-01153	3E-02	3E-02 -	8E-02	9E-02	3E-02 -	4E-02
3E	A	Personal	TWA	2-01155	0E+00	0E+00 -	7E-02	1E-01	4E-02 -	5E-02
3E	A	Stationary	TWA	2-01143	0E+00	0E+00 -	5E-03	0E+00	0E+00 -	1E-03
3E	A	Stationary	TWA	2-01144	0E+00	0E+00 -	2E-02	0E+00	-2E-05 -	2E-03
3E	A	Stationary	TWA	2-01145	0E+00	0E+00 -	5E-03	0E+00	-2E-05 -	2E-03
3E	A	Stationary	TWA	2-01146	0E+00	0E+00 -	5E-03	3E-03	1E-03 -	2E-03
3E	A	Stationary	TWA	2-01147	0E+00	0E+00 -	5E-03	1E-03	9E-04 -	2E-03
3E	A	Stationary	TWA	2-01148	0E+00	0E+00 -	3E-02	1E-03	8E-04 -	4E-03
3E	A	Stationary	TWA	2-01156	0E+00	0E+00 -	8E-03	2E-03	1E-03 -	2E-03
3E	A	Stationary	TWA	2-01157	0E+00	0E+00 -	8E-03	2E-03	1E-03 -	2E-03
3E	B	Personal	--	2-01013	7E-01	4E-01 -	8E-01	2E+00	4E-01 -	4E-01
3E	B	Personal	--	2-01133	8E-01	3E-01 -	4E-01	1E+00	2E-01 -	3E-01
3E	B	Personal	--	2-01134	5E-01	2E-01 -	2E-01	9E-01	2E-01 -	2E-01
3E	B	Personal	--	2-01136	6E-01	2E-01 -	3E-01	2E+00	3E-01 -	3E-01
3E	B	Personal	EXC	2-01015	2E-01	1E-01 -	4E-01	7E-01	2E-01 -	2E-01
3E	B	Personal	EXC	2-01017	6E-01	3E-01 -	5E-01	2E+00	3E-01 -	4E-01
3E	B	Personal	TWA	2-01039	0E+00	0E+00 -	8E-01	5E-01	2E-01 -	2E-01
3E	B	Personal	TWA	2-01101	8E-01	6E-01 -	1E+00	4E-01	1E-01 -	2E-01
3E	B	Personal	TWA	2-01014	2E-01	8E-02 -	1E-01	3E-01	5E-02 -	6E-02
3E	B	Personal	TWA	2-01016	3E-01	1E-01 -	1E-01	4E-01	6E-02 -	7E-02
3E	B	Stationary	TWA	2-01007	0E+00	0E+00 -	8E-03	2E-03	1E-03 -	3E-03
3E	B	Stationary	TWA	2-01008	0E+00	0E+00 -	8E-03	1E-03	8E-04 -	2E-03
3E	B	Stationary	TWA	2-01009	0E+00	0E+00 -	8E-03	3E-03	2E-03 -	3E-03
3E	B	Stationary	TWA	2-01010	0E+00	0E+00 -	8E-03	1E-03	1E-03 -	2E-03
3E	B	Stationary	TWA	2-01018	3E-03	3E-03 -	1E-02	1E-02	4E-03 -	5E-03
3E	B	Stationary	TWA	2-01019	0E+00	0E+00 -	9E-03	2E-03	1E-03 -	3E-03
3E	B	Stationary	TWA	2-01121	0E+00	0E+00 -	2E-03	2E-03	1E-03 -	2E-03
3E	B	Stationary	TWA	2-01122	0E+00	0E+00 -	2E-03	3E-03	1E-03 -	2E-03
3E	B	Stationary	TWA	2-01123	0E+00	0E+00 -	2E-03	2E-03	8E-04 -	2E-03
3E	B	Stationary	TWA	2-01124	0E+00	0E+00 -	2E-03	1E-03	8E-04 -	1E-03
3E	B	Stationary	TWA	2-01125	0E+00	0E+00 -	3E-03	2E-03	1E-03 -	3E-03
3E	B	Stationary	TWA	2-01126	0E+00	0E+00 -	2E-03	8E-04	6E-04 -	1E-03
3E	B	Stationary	TWA	2-01129	0E+00	0E+00 -	7E-03	2E-03	1E-03 -	2E-03
3E	B	Stationary	TWA	2-01130	0E+00	0E+00 -	7E-03	5E-03	2E-03 -	3E-03
3E	B	Stationary	TWA	2-01131	0E+00	0E+00 -	7E-03	3E-03	1E-03 -	2E-03
3E	B	Stationary	TWA	2-01137	0E+00	0E+00 -	2E-03	2E-03	1E-03 -	2E-03
3E	B	Stationary	TWA	2-01140	0E+00	0E+00 -	7E-03	2E-03	1E-03 -	2E-03
3E	C	Personal	EXC	2-01094	0E+00	0E+00 -	7E-01	9E-02	6E-02 -	1E-01
3E	C	Personal	EXC	2-01095	0E+00	0E+00 -	3E-01	6E-02	4E-02 -	1E-01

Table 7-4
Summary of Air Samples Utilized in the PCM vs. TEM Evaluation

Scenario	Property ID	Personal/ Stationary	Sample Type	Index ID	TEM (a) Air Conc (s/cc)	TEM (a) 90% Poisson CI			PCM Air Conc (s/cc)	PCM 90% Poisson CI		
3E	C	Personal	EXC	2-01164	0E+00	0E+00	-	2E-01	3E-02	2E-02	-	8E-02
3E	C	Personal	EXC	2-01166	0E+00	0E+00	-	2E-01	3E-02	2E-02	-	9E-02
3E	C	Personal	TWA	2-01084	2E-02	2E-02	-	5E-02	4E-02	2E-02	-	2E-02
3E	C	Personal	TWA	2-01086	4E-02	3E-02	-	6E-02	9E-02	2E-02	-	3E-02
3E	C	Personal	TWA	2-01163	0E+00	0E+00	-	2E-02	0E+00	-5E-05	-	5E-03
3E	C	Personal	TWA	2-01165	0E+00	0E+00	-	2E-02	2E-03	2E-03	-	4E-03
3E	C	Stationary	TWA	2-01088	3E-03	3E-03	-	1E-02	5E-03	3E-03	-	5E-03
3E	C	Stationary	TWA	2-01089	0E+00	0E+00	-	1E-02	3E-03	2E-03	-	5E-03
3E	C	Stationary	TWA	2-01090	0E+00	0E+00	-	1E-02	2E-03	2E-03	-	4E-03
3E	C	Stationary	TWA	2-01091	0E+00	0E+00	-	1E-02	3E-03	2E-03	-	4E-03
3E	C	Stationary	TWA	2-01092	0E+00	0E+00	-	2E-02	3E-03	3E-03	-	7E-03
3E	C	Stationary	TWA	2-01096	0E+00	0E+00	-	8E-03	1E-03	9E-04	-	2E-03
3E	C	Stationary	TWA	2-01097	0E+00	0E+00	-	8E-03	6E-04	5E-04	-	2E-03
3E	C	Stationary	TWA	2-01098	0E+00	0E+00	-	8E-03	8E-04	7E-04	-	2E-03
3E	C	Stationary	TWA	2-01099	0E+00	0E+00	-	8E-03	1E-03	9E-04	-	2E-03
3E	C	Stationary	TWA	2-01100	0E+00	0E+00	-	8E-03	2E-03	1E-03	-	2E-03
3E	C	Stationary	TWA	2-01167	2E-03	2E-03	-	9E-03	2E-03	9E-04	-	2E-03
3E	C	Stationary	TWA	2-01168	2E-03	2E-03	-	9E-03	3E-03	1E-03	-	3E-03
4	Z	Personal	TWA	2-01187	7E-02	6E-02	-	2E-01	2E-01	5E-02	-	6E-02
4	Z	Personal	EXC	2-01188	9E-02	8E-02	-	2E-01	3E-01	8E-02	-	1E-01
4	Z	Personal	EXC	2-01190	0E+00	0E+00	-	1E-01	0E+00	0E+00	-	3E-02
4	Z	Personal	TWA	2-01191	0E+00	0E+00	-	6E-02	2E-02	1E-02	-	2E-02
4	Z	Personal	EXC	2-01192	3E-02	3E-02	-	1E-01	2E-02	1E-02	-	4E-02
4	Z	Stationary	TWA	2-01195	0E+00	0E+00	-	2E-02	0E+00	0E+00	-	4E-03
4	Z	Stationary	TWA	2-01196	3E-03	2E-03	-	1E-02	7E-03	4E-03	-	9E-03
4	Z	Stationary	TWA	2-01197	0E+00	0E+00	-	2E-02	9E-03	5E-03	-	8E-03
4	Z	Stationary	TWA	2-01198	5E-03	4E-03	-	1E-02	3E-02	1E-02	-	1E-02

(a) TEM air concentrations based on $PCME_{LA}$

Table 7-5
Comparison of PCM Personal Air Concentrations During Scenario Activities to OSHA Standards

Comparison to Time-Weighted Average (TWA) of 0.1 f/cc

Scenario	N Samples	N > TWA	% > TWA	Mean (f/cc)	Max (f/cc)
1 (Routine Activities)	11	0	0%	0.007	0.02
2 (Active Cleaning)	45	9	20%	0.11	1.0
3 (Active Disturbance)	10	4	40%	0.24	1.6
4 (Rototilling)	2	1	50%	0.12	0.23

Comparison to Short-term Exposure Limit (STEL) of 1 f/cc

Scenario	N Samples	N > STEL	% > STEL	Mean (f/cc)	Max (f/cc)
1 (Routine Activities)	0	--	--	--	--
2 (Active Cleaning)	77	4	5%	0.13	1.8
3 (Active Disturbance)	25	2	8%	0.40	3.7
4 (Rototilling)	3	0	0%	0.09	0.27

Table 7-5_OSHA Comparisons.xls, 3/29/2006

Table 7-6
Estimation of Dust to Air Transfer Coefficient for Scenario 1 (Routine Activities)

Random House ID	Personal Air Samples		Dust Samples[a]		House Mean Dust Loading[b] (s/cm^2)	Ratio (Air/Dust)
	Sample ID	Air Conc (s/cc)	Sample ID	Dust Loading (s/cm^2)		
AA	2-00071	ND	2-00548	ND	ND	NC
AB	2-00076	ND	ns			NC
AC	2-00004	ND	2-00421	ND	ND	NC
B	2-00080	ND	ns			NC
D	2-00018	0.0007	ns			NC
E	ns		2-00964	ND	41	NC
			2-01346	ND		
			2-01347	122		
F	ns		2-00386	ND	ND	NC
G	2-00247	0.0020	2-00627	ND	ND	NC
I	ns		2-01247	190	980	NC
			2-01248	1,770		
J	ns		2-00896	ND	ND	NC
M	2-00165	ND	2-00863	1,132	1,132	NC
N	2-00155	0.0005	2-00678	ND	ND	NC
O	2-00026	ND	2-01051	ND	ND	NC
P	ns		2-00473	ND	ND	NC
Q	2-00022	0.0013	ns			NC
R	2-00035	ND	ns			NC
S	2-01041	ND	ns			NC
T	2-00001	ND	2-00456	ND	ND	NC
U	2-00044	ND	ns			NC
X	2-00040	ND	2-00822	ND	ND	NC
Y	2-00030	ND	2-00506	3,397	3,397	NC

[a] Dust IDs represent Scenario 2 samples that were collected prior to the commencement of cleaning activities.
[b] Averaged across all dust samples within a house. Non-detects evaluated at 0.

TEM results based on Total LA
ns = no sample collected
ND = non-detect
NC = not calculated; one or both samples were non-detect.

Table 7-7
Estimation of Dust to Air Transfer Coefficient for Disturbance Activities (Scenarios 2A, 2B, and 3C)

Part A: Scenario 2A, Active Cleaning (Sweeping, Dusting, Vacuuming)

Random House ID	Personal Air Samples[a]		House Mean Air Conc[c] (s/cc)	Dust Samples[b]		House Mean Dust Loading[c] (s/cm^2)	Ratio (Air/Dust)
	Sample ID	Air Conc (s/cc)		Sample ID	Dust Loading (s/cm^2)		
A	2-00067	0.006	0.006	ns			NC
AA	2-00537	0.007	0.005	2-00548	ND	ND	NC
	2-00542	0.003					
AC	2-00408	0.107	0.053	2-00421	ND	ND	NC
	2-00411	ND					
B	2-00341	ND	ND	ns			NC
	2-00344	ND					
C	2-00149	ND	ND	ns			NC
	2-00152	ND					
D	2-00186	ND	ND	ns			NC
	2-00188	ND					
	2-00240	ND					
	2-00243	ND					
E	2-00090	ND	ND	2-00964	ND	ND	NC
	2-00091	ND					
	2-00975	0.005					
	2-00979	ND					
F	2-00379	ND	ND	2-00386	ND	ND	NC
	2-00382	ND					
G	2-00642	0.005	0.008	2-00627	ND	ND	NC
	2-00646	0.012					
I	2-01231	ND	ND	2-01247	190	980	NC
	2-01236	ND		2-01248	1,770		
J	2-00921	ND	ND	2-00896	ND	ND	NC
M	2-00874	ND	ND	2-00863	1,132	1,132	NC
	2-00878	ND					
N	ns			2-00678	ND	ND	NC
O	2-01062	0.002	ND	2-01051	ND	ND	NC
	2-01066	ND					
P	2-00793	ND	ND	2-00473	ND	ND	NC
	2-00797	ND					
Q	2-00209	ND	ND	ns			NC
	2-00211	ND					
T	2-00443	ND	ND	2-00456	ND	ND	NC
	2-00446	ND					
U	2-00300	0.021	0.010	ns			NC
	2-00302	ND					
V	2-00114	0.008	0.008	ns			NC
X	2-00273	ND	ND	2-00822	ND	ND	NC
	2-00275	ND					
X (garage)	2-00834	ND	ND	ns			NC
	2-00839	ND					
Y	2-00499	ND	ND	2-00506	3,397	3,397	NC
	2-00502	ND					

Table 7-7
Estimation of Dust to Air Transfer Coefficient for Disturbance Activities (Scenarios 2A, 2B, and 3C)

Part B: Scenario 2B, Beating Cushions

Random House ID	Personal Air Samples[a]		House Mean Air Conc[c] (s/cc)	Dust Samples[b]		House Mean Dust Loading[c] (s/cm^2)	Ratio (Air/Dust)
	Sample ID	Air Conc (s/cc)		Sample ID	Dust Loading (s/cm^2)		
E	2-01344	0.016	0.016	2-01346	ND	61	0.0003
				2-01347	122		

Part C: Scenario 3C, Carpet Removal

Random House ID	Personal Air Samples[a]		House Mean Air Conc[c] (s/cc)	Dust Samples[b]		House Mean Dust Loading[c] (s/cm^2)	Ratio (Air/Dust)
	Sample ID	Air Conc (s/cc)		Sample ID	Dust Loading (s/cm^2)		
A	2-00058	0.006	0.006	ns			NC
N	2-00693	ND	ND	ns			NC
	2-00697	0.004					
E	2-01278	0.093	0.046	2-01264	ND	ND	NC
	2-01282	ND		2-01265	ND		

[a] Personal Air IDs represent full period samples that were collected during scenario-related activities.
[b] Dust IDs represent samples that were collected prior to the commencement of scenario-related activities.
[c] Averaged across all air or dust samples within a house. Non-detects evaluated at 0.

TEM results based on Total LA
ns = no sample collected
ND = non-detect
NC = not calculated; one or both samples were non-detect.

Table 7-8
Air, Bulk Insulation, and Garden Soil Results from Scenarios 3 and 4

Scenario 3 Air Samples and Bulk Insulation

Scenario	Random House ID	Personal Air Samples[a]		Bulk Insulation Samples	
		Sample ID	TEM Air Conc (s/cc)	Sample ID	PLM Result
3A/B	B	2-01027	0.96	2-01005	<1
				2-01006	<1
				1-01861	<1
	K	2-00572	0.68	2-00596	<1
		2-00588	0.047	2-00597a	ND
				2-00597b	<1
				2-00616a	ND
				2-00616b	ND
	L	2-00739	0.33	2-00786	<1
		2-00744	0.15	2-00787	<1
3E	C	2-01084	0.049	1-01954	<1
		2-01086	0.062		
		2-01163	ND		
		2-01165	ND		
	A	2-01153	0.087	2-00068	<1
		2-01155	ND	2-00069	<1
				2-00070	<1
				1-01965	<1
	B	2-01014	0.39	2-01005	<1
		2-01016	0.47	2-01006	<1
				1-01861	<1

3A/B - sweeping debris, simulated remodeling, cutting holes into ceilings/walls

3E - removal of vermiculite via vacuum truck

Scenario 4 Air Samples and Garden Soil

Scenario	Random House ID	Personal Air Samples[a]		Garden Soil Samples	
		Sample ID	TEM Air Conc (s/cc)	Sample ID	PLM Result
4	Z	2-01187	0.066	1-01398	ND
		2-01191	ND	1-02979	<1

[a] Personal Air IDs represent full period samples that were collected during scenario-related activities.
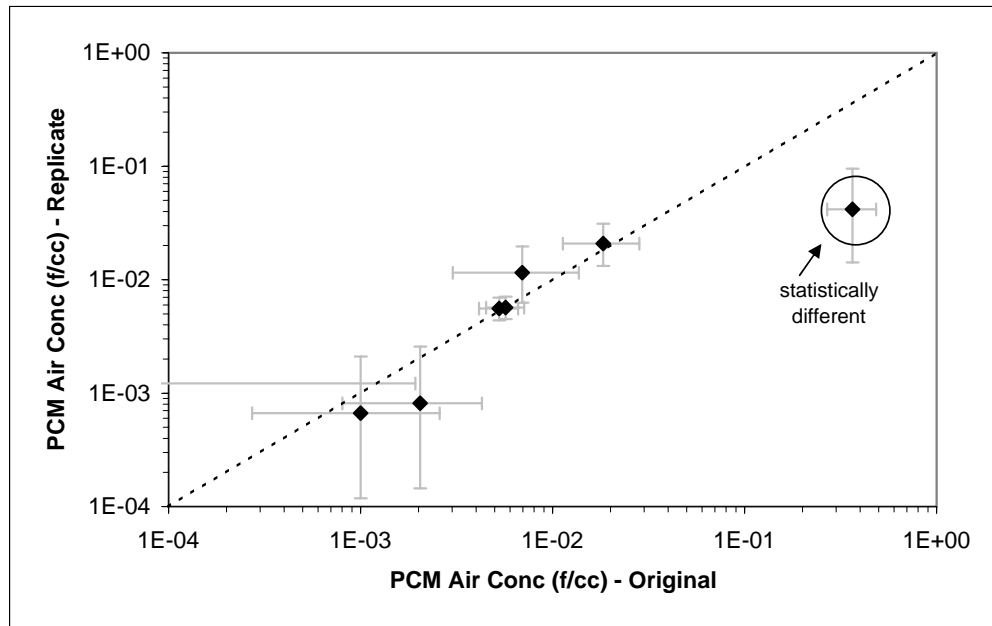
TEM results based on Total LA

PLM results based on Tremolite/Actinolite

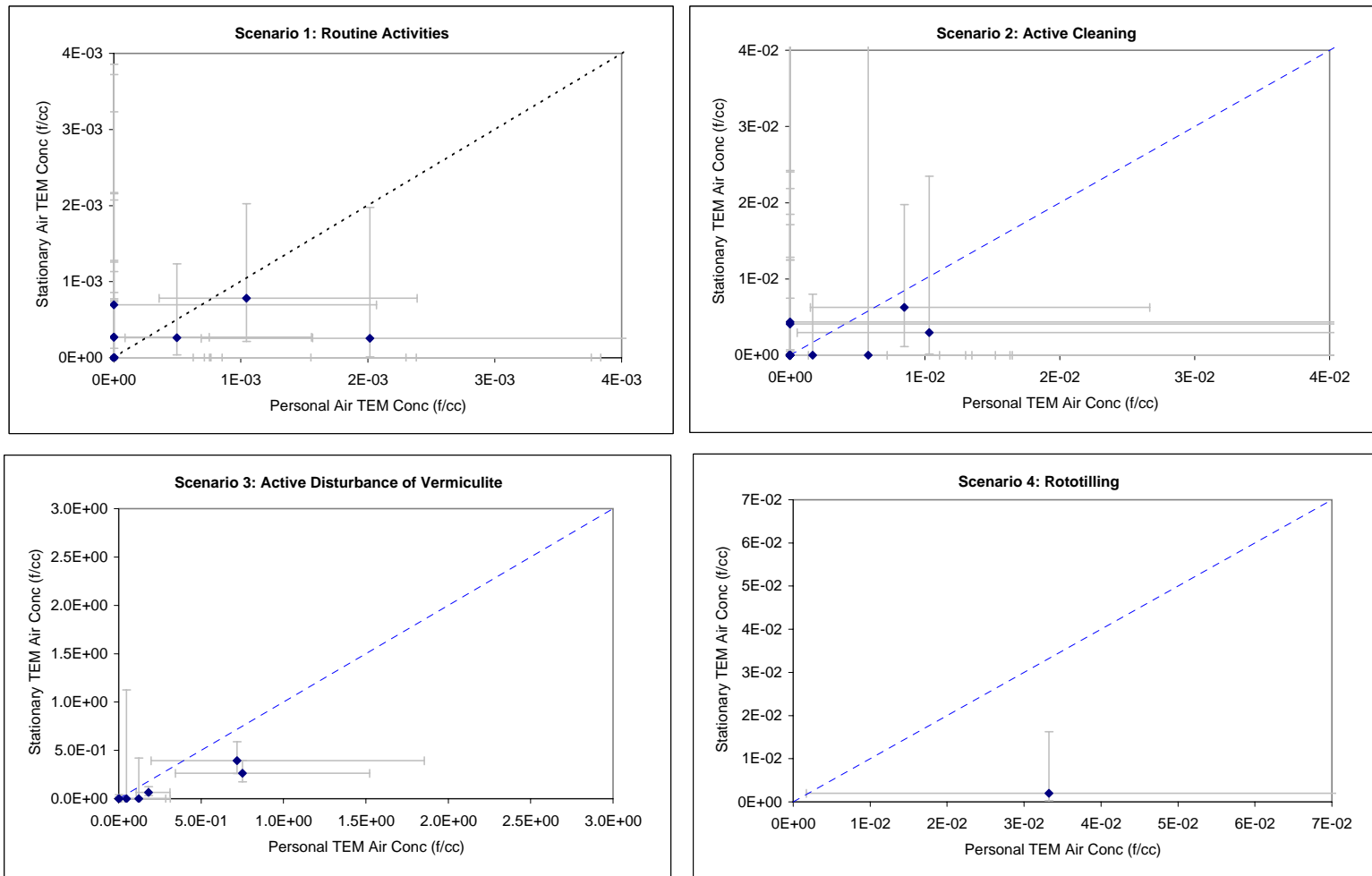ns = no sample collected

ND = non-detect

FIGURES

Figure 5-1
Comparison of PCM Air Concentrations in Replicate Samples

Non-detects cannot be plotted on a log-scale, but error bars for these samples are shown.

Figure 7-1
**Comparison of Personal and Stationary TEM Air Concentrations During Scenario Activities**

TEM air concentrations based on PCMEla

	Personal					Stationary					Method 1		Method 2
Scenario	N Samples	N Houses	Mean	StDev	Min	Max	N Samples	N Houses	Mean	StDev	Min	Max	N Detect Pairs	Mean	Mean
Sc1	16	16	0.0002	0.0006	0.00	0.0020	26	16	0.0002	0.0003	0.00	0.0008	3	3.7	1.4
Sc2	43	23	0.0011	0.0029	0.00	0.0103	34	23	0.0008	0.0018	0.0000	0.0063	2	2.4	1.5
Sc3	11	7	0.2599	0.3304	0.00	0.7507	12	7	0.1033	0.1603	0.00	0.3941	3	2.5	2.5
Sc4	2	1	0.0332	--	0.0332	0.0332	4	1	0.0020	--	0.0020	0.0020	1	16.6	16.6

Method 1: Mean of personal/stationary ratios, includes only those personal/stationary pairs that were both detect.

Method 2: Mean personal/mean stationary, includes all samples.

Figure 7-2
**Comparison of Personal and Stationary PCM Air Concentrations During Scenario Activities**
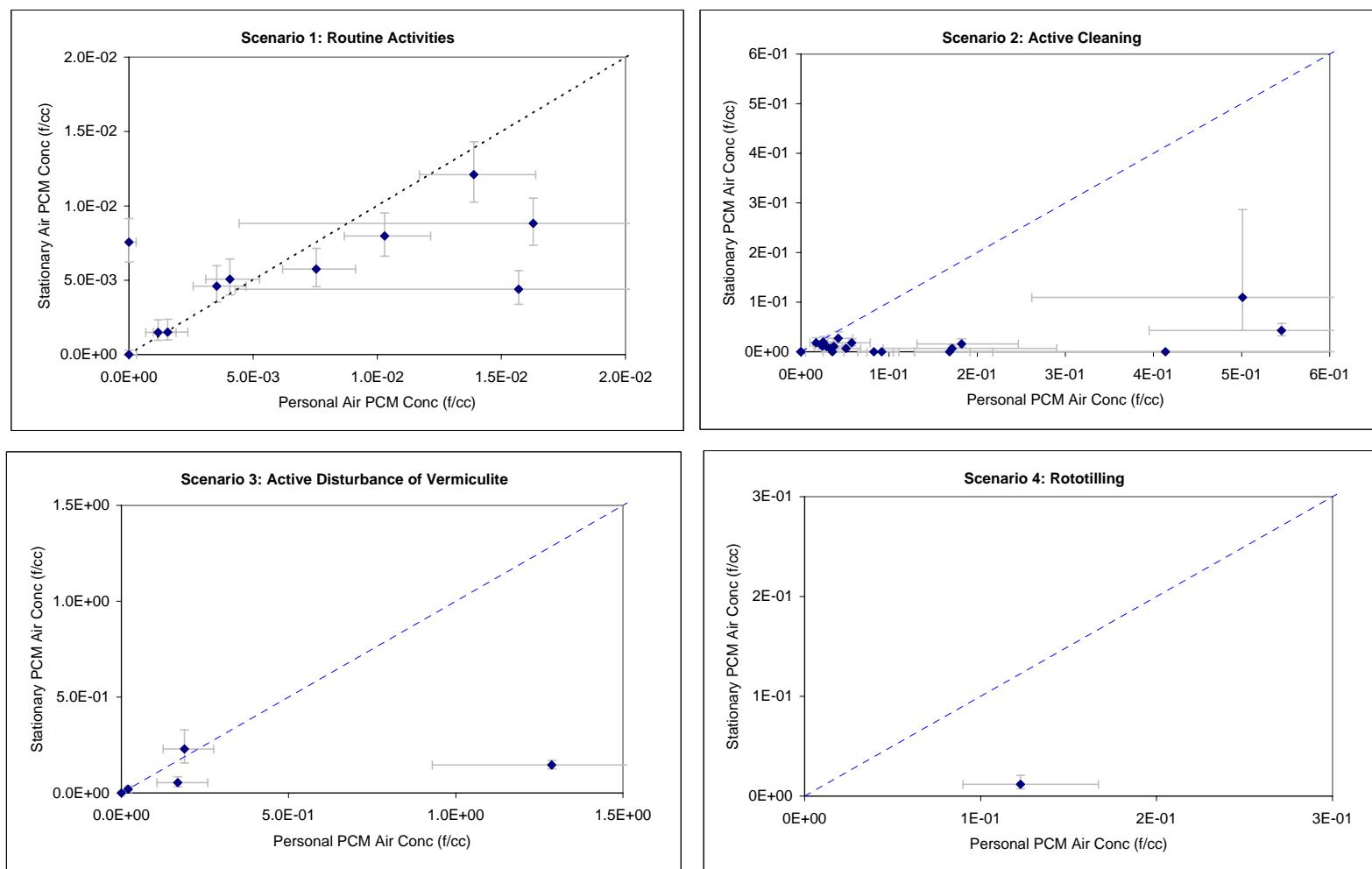
	Personal					Stationary					Method 1		Method 2
Scenario	N samples	N houses	Mean	StDev	Min	Max	N samples	N houses	Mean	StDev	Min	Max	N Detect Pairs	Mean	Mean
Sc1	11	11	0.0067	0.0063	0.00	0.0163	23	14	0.0048	0.0034	0.00	0.0121	9	1.4	1.4
Sc2	39	21	0.1241	0.1616	0.00	0.5452	23	15	0.0965	0.2869	0.0068	1.1292	15	5.6	1.3
Sc3	10	6	0.2796	0.5006	0.00	1.2874	9	5	0.0902	0.0961	0.00	0.2302	4	3.4	3.1
Sc4	2	1	0.1227	--	0.1227	0.1227	4	1	0.0118	--	0.0118	0.0118	1	10.4	10.4

Method 1: Mean of personal/stationary ratios, includes only those personal/stationary pairs that were both detect.
Method 2: Mean personal/mean stationary, includes all samples.

Figure 7-3
Comparison of TEM and PCM Air Concentrations in Samples Collected During Scenario Activities
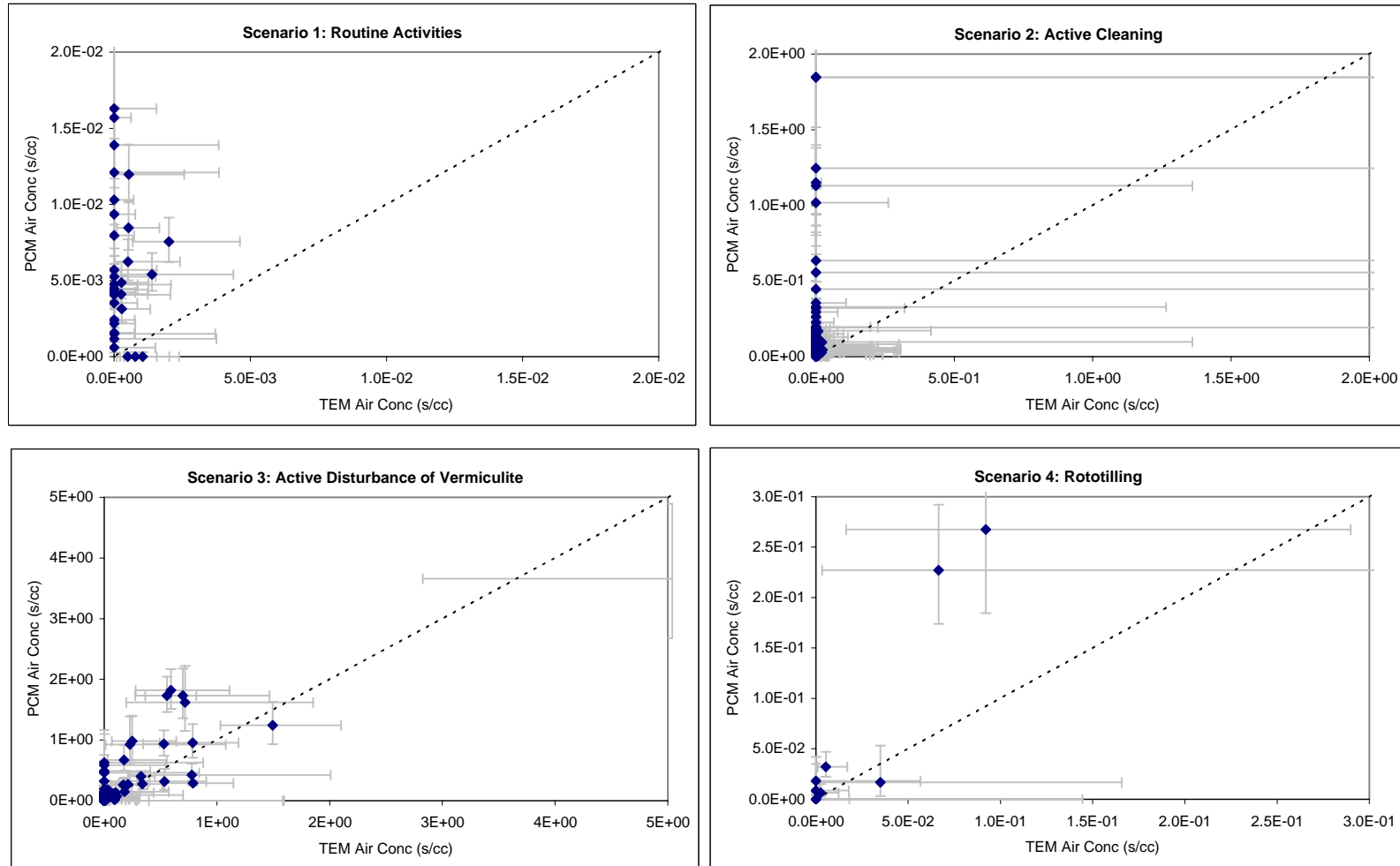

TEM Air Concentrations based on PCMEla

Scenario	N samples	TEM Air Conc (s/cc)			PCM Air Conc (s/cc)			Method 1	Method 2
		Mean	Min	Max	Mean	Min	Max		
Sc1	34	0.00024	0.00	0.0020	0.0056	0.00	0.016	23.3	9.4
Sc2	205	0.0010	0.00	0.02	0.098	0.00	1.8	95.5	8.4
Sc3	118	0.13	0.00	5.0	0.20	0.00	3.7	1.6	1.9
Sc4	9	0.022	0.00	0.09	0.064	0.00	0.27	2.9	3.1

Method 1: Mean of PCM/TEM ratios, includes only those samples that were both detect.
Method 2: Mean PCM/mean TEM, includes all samples.

Figure 7-4
Length and Width Measurements for LA Structures Observed
in TEM Analyses for Air Samples Collected from the Libby Site
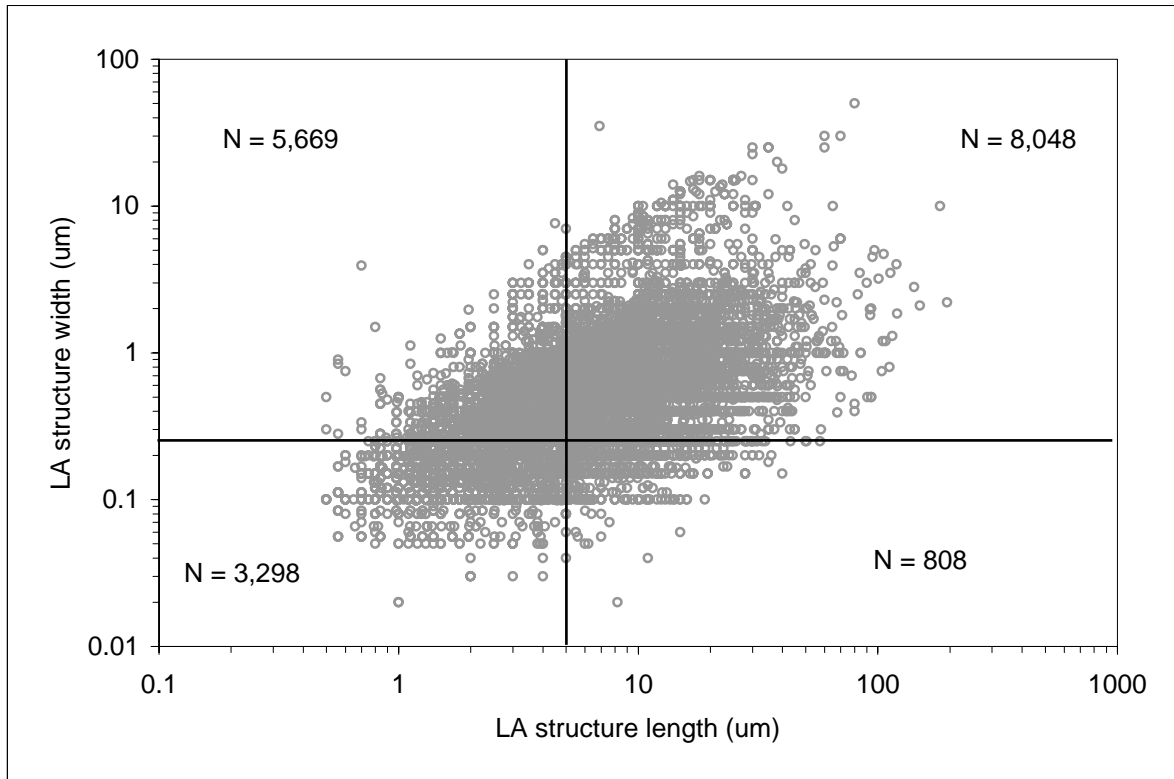
Based on all LA structures longer than 0.5 um oberved in TEM analyses (ISO or AHERA) of air field samples from the Libby site (N = 17,823 LA structures).

Database download on February 7, 2006.

Fig 7-4_TEM LA struc dist.xls

Figure 7-5

RAM Results, Personal Sample 2-00304, Collected During Active Cleaning

Mean Dust Level = 0.62 mg/m^3

Max Dust Level = 16.3 mg/m^3

TEM-ISO Result: Non-Detect
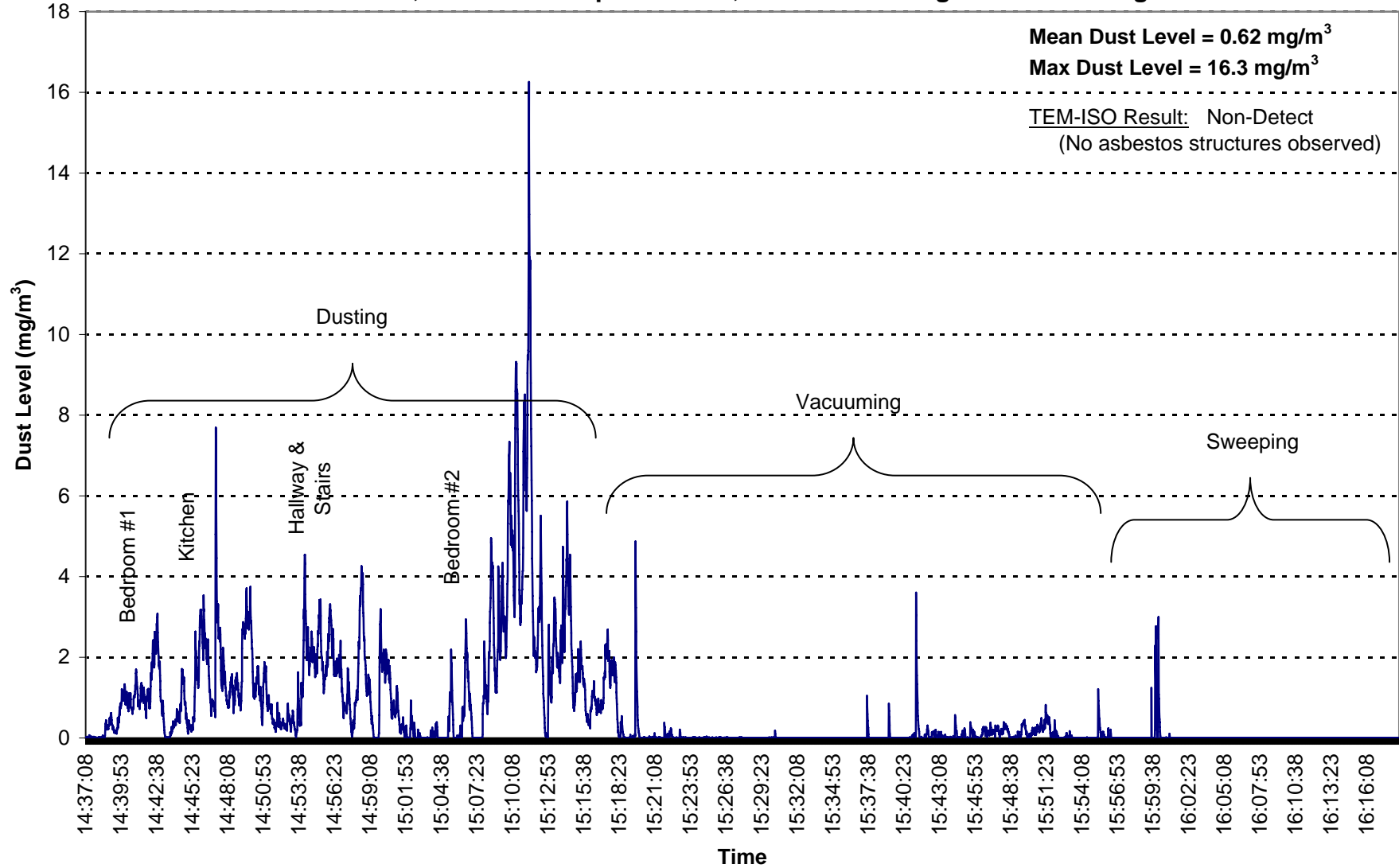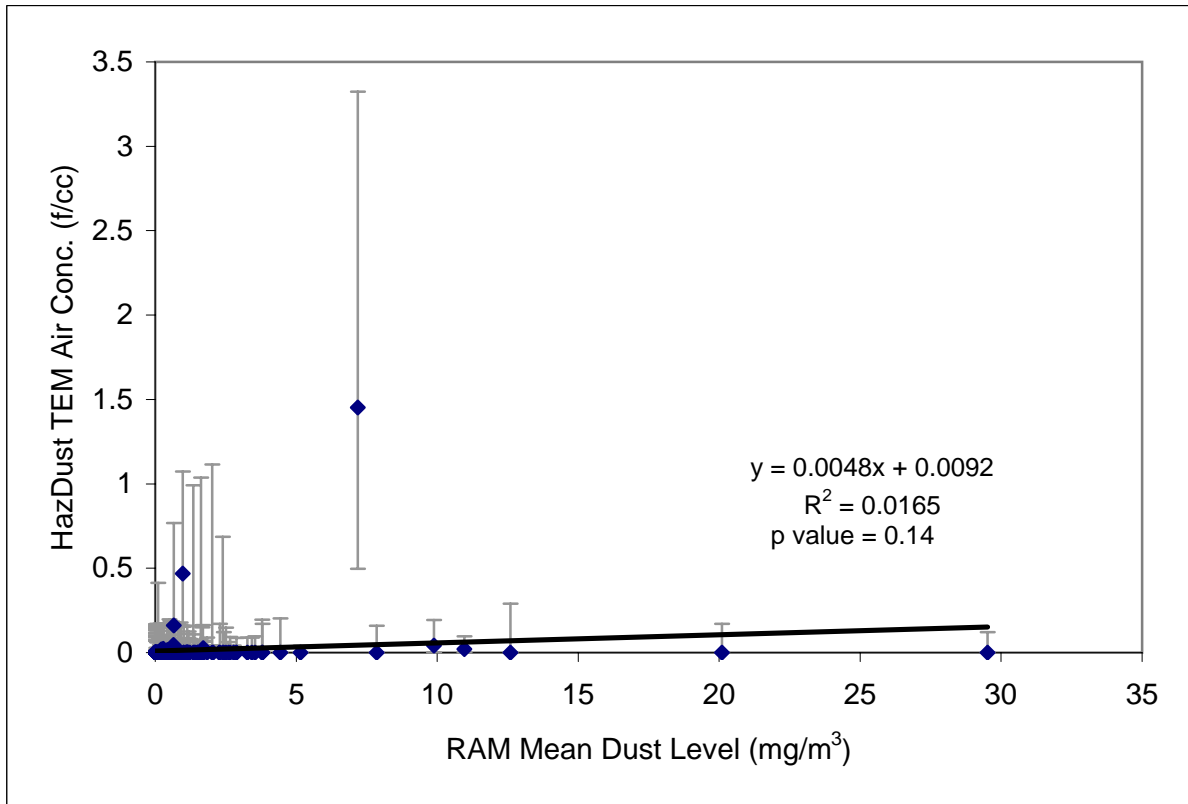 (No asbestos structures observed)

Fig 7-5_Example Output Fig.xls, 3/31/2006

Figure 7-6
Correlation of RAM Dust Levels and HazDust TEM Air Concentrations

TEM Air Concentrations based on Total LA

Fig 7-6_HazDust Summ Stats v2.xls, 3/31/2006

APPENDIX A
Field Modification Forms
(provided electronically on the attached CD)

APPENDIX B
Libby Phase 2 Database
(provided electronically on the attached CD)

APPENDIX C
Field Replicate/Duplicate Sample Results

APPENDIX D
Laboratory-Based QC Sample Results

APPENDIX E
Summary of the TEM, PCM, and PLM Phase 2 Field Sample Results